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Early Cretaceous Freshwater Fish Fauna in Kyushu, Japan

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Abstract The Wakino Subgroup in the Kwanmon Group at Kitakyushu City in the northern part of Kyushu, Japan, has a rich yield of freshwater fish fossils. Twenty-one species, 8 genera and 6 families are described in the present study, among them, 15 species are described as new, plus 4 new genera *Nipponamia, Aokiichthys, Wakinoichthys* and *Paraleptolepis*; and 2 new families, Chuhsiungichthiidae and Wakinoichthiidae, are established. Three different paleoichthyofaunas are recognized in the Wakino Subgroup. The *Nipponamia-Aokiichthys*, the *Paraleptolepis-Wakinoichthys* and *Diplomystus-Wakinoichthys* faunas are proposed to designate them. The name Wakino fish fauna is proposed for the entire ichthyofauna of the Wakino Subgroup. It is composed of the primitive halecostome orders Semionotiformes and Amiiformes, and the primitive teleostean orders Ichthyodectiformes, Osteoglossiformes and Clupeiformes. In numbers of species and individuals, osteoglossiform and clupeiform fishes are most abundant. This fish fauna is the only freshwater one known from the Mesozoic of Japan.

The *Nipponamia-Aokiichthys* fauna is found in the First Formation (W_1). This fauna consists of *Lepidotes macropterus* sp. nov. of the order Semionotiformes, *Nipponamia satoi* gen. et sp. nov. of the Amiiformes, *Chuhsiungichthys yanagidai* sp. nov. of the Ichthyodectiformes, and *Aokiichthys toriyamai* gen. et sp. nov., *A. changae* gen. et sp. nov., *A. otai* gen. et sp. nov. and *A. uyenoi* gen. et sp. nov., *A. praedorsalis* gen. et sp. nov., and *A.* sp. of the Osteoglossiformes. Among these, the order Osteoglossiformes are the most abundant in numbers of species and individuals. The *Paraleptolepis-Wakinoichthys* fauna is found in the Third Formation (W_3). This fauna is composed of *Paraleptolepis kikuchii* gen. et sp. nov. and *P. elegans* gen. et sp. nov. of the order and family *incertae sedis*, *Chuhsiungichthys* sp. of the Ichthyodectiformes, and *Wakinoichthys aokii* gen. et sp. nov. and *W. robustus* gen. et sp. nov. of the Osteoglossiformes. Fishes of the genera *Paraleptolepis* and *Wakinoichthys* are the most abundant. The *Diplomystus-Wakinoichthys* fauna is found in the Fourth Formation (W_4), and composed of *Chuhsiungichthys japonicus* sp. nov. of the order Ichthyodectiformes, *Yungkangichthys macrodon* sp. nov. and *Wakinoichthys aokii* gen. et sp. nov. of the Osteoglossiformes, and *Diplomystus primotinus, D. kokuraensis, D. altisomus* sp. nov. and *D.* sp. of the Clupeiformes, with the genus *Diplomystus* being most abundant. No fish fossils have been found in the Second Formation (W_2).

Among the Wakino fish faunas, the *Nipponamia-Aokiichthys* fauna is closest to the *Mesoclupea* assemblage from southeastern China. Four families: Semionotidae, Amiidae, Chuhsiungichthiidae and Lycopteridae; and one genus, *Lepidotes*, are common in both faunas. The *Paraleptolepis-Wakinoichthys* and *Diplomystus-Wakinoichthys* faunas are considered to be endemic. In comparison with the Cretaceous freshwater fish faunas of the world, the Wakino fish fauna is characterized by the abundance of the Osteoglossiformes and Clupeiformes.

It is considered that the *Nipponamia-Aokiichthys* fauna became extinct by the end of the First Formation (W_1) or the beginning of the Second Formation (W_2). On the basis of this study, it is hypothesized that the clupeid fishes of the Fourth Formation entered the Kowakino-ko Lake from sea at the beginning of this period, and took its place as the most abundant fish, *Paraleptolepis*, of the *Paraleptolepis-Wakinoichthys* fauna.

Contents

Introduction

Mesozoic lacustrine sediments are distributed in western Honshu through northern Kyushu, Japan. Many geological and paleontological studies have been done on the Mesozoic sediments in this area (SUZUKI, 1893, 1906; KOCHIBE, 1903; KOTO, 1909; OGURA, 1922; YABE, 1927; NAGAO, 1929; KOBAYASHI, 1931; OISHI, 1933; TORIYAMA, 1938; KOBAYASHI and OTA, 1936; KOBAYASHI and SUZUKI; 1936, 1939; KOBAYASHI, 1941; MATSUMOTO, 1949, 1951, 1954; Y. OTA, 1953, 1955, 1957, 1958, 1959a-d, 1960ab; UEDA, 1957; HASE, 1958, 1960; M. OTA *et al.*, 1979; UYENO, 1979; UYENO and YABUMOTO, 1980; KUSUMI, 1960, 1979; ISHIJIMA, 1978, 1979; TAMURA, 1990; KIMURA *et al.*, 1992).

The first record of non-marine fossils from the Mesozoic sediments in northern Kyushu was on molluscs from Wakino in Nogata City, Fukuoka Prefecture by NAGAO (1929). KOBAYASHI and SUZUKI (1936) described five non-marine molluscs from Wakino. KOBAYASHI and OTA (1936) designated this shell bearing formation as the Wakino beds and stated that the beds were correlated to the Naktong Series of South Korea, which has been considered to be referable to the Lower Cretaceous on the

basis of similarity of the fossil assemblage. MATSUMOTO (1951) proposed to designate the so-called "Inkstone Series" as the Kwanmon Group, which consists of two subgroups: the lower Wakino Subgroup and the upper Shimonoseki Subgroup, based on the established stratigraphic column of the type area. In 1954, MATSUMOTO presented a general description and discussion of the Kwanmon Group.*

The stratigraphy of the Kwanmon Group was established by Y. OTA (1953, 1955, 1957, 1958, 1959a-d, 1960ab) and HASE (1958, 1960). The type area of the Wakino Subgroup was reexamined and four formations were recognized: the Sengoku Formation, the Nyoraida Formation, the Lower Wakamiya Formation and the Upper Wakamiya Formation, in ascending order (Y. OTA, 1953). Y. OTA (1955, 1957, 1958, 1959a) reported on four other areas in northern Kyushu and recognized equivalents for these formations. UEDA (1957) investigated the type area of the Shimonoseki Subgroup. HASE (1958, 1960) stated on the stratigraphy and the geologic history of the Kwanmon Group and described molluscan species from the Toyonishi and the Kwanmon Groups. MATSUSHITA (1968) investigated the Kwanmon Group in Kitakyushu City. M. OTA *et al.* (1979) investigated the Wakino Subgroup at Yamada Park, a former military arsenal in the southern district of Kokura, Kitakyushu City, and reported the stratigraphy and geologic structure in detail, with a special reference to the occurrence of fish fossils.

The first record of the fish fossils from the Wakino Subgroup in the Kwanmon Group was from the First Formation (the lower formation, W_1) in southern Kokura in Kitakyushu City, Fukuoka Prefecture by Y. OTA (1955). Y. OTA (1957) reported that fish fossils were abundant in the uppermost formation (the Fourth Formation, W_4) at Kokura and in 1960, he noted that "fossil fish shows an isolated occurrence in a shale or associated with *Estherites*. Its body-side is generally parallel to the bedding plane" and "Fish (*Manchurichthys*(?) sp.) and *Estherites* occur rarely in the lower member (of W_3) .....". HASE (1958) recorded cfr. *Manchurichthys* sp. from the equivalent of the Lower Wakamiya Formation in Kokura, but there were no descriptions of the fossil fishes in any of the studies.

In 1975, more fragments of fossil fishes were found at Kumagai, Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, by students of Mr. Takashi SOTSUKA (Kitakyushu Senior High School) and were brought to Dr. Masamichi OTA of the Akiyoshidai Museum of Natural History. The fossil fish site is located on a cliff about 100 m northeast of the front gate of Yamada Park which is located almost at the center of Kitakyushu City. The site belongs to the Fourth Formation (the uppermost formation, W_4) of the Wakino Subgroup (M. OTA *et al.*, 1979).

Two excavations of the fossil fish site were made by a team of geologists and paleontologists organized by Dr. M. OTA and sponsored by the city of Kitakyushu in 1976 and 1977. This led to the establishment of a new museum, the Kitakyushu

* There is a recent tendency that the "Kwanmon" Group is spelled as the "Kanmon" Group.

Museum and Institute of Natural History, in this city. The advisor to the excavation team was the late Dr. Ryuzo TORIYAMA, who was professor emeritus of Kyushu University and later the first director of the Kitakyushu Museum and Institute of Natural History. The leader of the team was Dr. M. OTA who later became the second director of the Museum. As a result of these efforts, UYENO (1979) described two new species belonging to the clupeoid fish genus *Diplomystus*: *D. primotinus* and *D. kokuraensis*. At the time of the excavations, fragments of several species of other fishes belonging to the primitive teleostean family Lycopteridae and others were collected, along with conchostracans of the family Lioestheriidae (KUSUMI, 1979) and a colony of blue-green algae, *Endophycus wakinoensis* (ISHIJIMA, 1978, 1979). Among these fish fossils, one osteoglossiform fish was recognized (YABUMOTO, 1989). Along with the excavations, the geology of Yamada Park was investigated (M. OTA *et al.*, 1979).

In 1988, Mr. Tateyu AOKI brought in some well preserved specimens from the excavation site of 1976 and 1977, and from a cliff near the Mitsubishi Material Co. Ltd. cement plant, and donated them to the Kitakyushu Museum and Institute of Natural History. These specimens are found to belong to the orders Ichthyodectiformes and Osteoglossiformes (YABUMOTO and UYENO, 1989). This led to an excavation of the cliff site at the cement plant by the Kitakyushu Museum and Institute of Natural History in 1990.

In 1989, Mr. T. AOKI and Mr. Masahiro SATO found a new fish fossil site at Tokuriki, Kokura-minami-ku (Kokura Southern Ward) in Kitakyushu City. This fossil fish site which is located about 3.5 km south of the first fish fossil site, was under construction for housing. This site belongs to the First Formation (the lower formation, W_1) of the Wakino Subgroup. Mr. AOKI and Mr. SATO helped me excavating fish fossils at this new site and assisted in fossil preparation. These fossils belong to the Order Semionotiformes, Amiiformes, Ichthyodectiformes, and Osteoglossiformes (YABUMOTO *et al.*, 1990; YABUMOTO, 1991, 1992).

Mr. Naoki KIKUCHI, a student at Kochi University collected some specimens from yet another fish fossil site which is located about 600 m southeast of the first fossil site. This fossil site belongs to the Third Formation (the upper formation, W_3) of the Wakino Subgroup.

Thus, fish fossils have been found in three formations: the First Formation (the lower formation, W_1), the Third Formation (the upper formation, W_3), and the Fourth Formation (the uppermost formation, W_4) in the Wakino Subgroup. These fish faunas are different from each other. In this study, the present author recognized 21 fish species and described them as new Cretaceous freshwater fish faunas, which include 15 new species, 4 new genera and 2 new families. These three fish faunas in the Wakino Subgroup are mutually compared and the farther comparison is made with other Cretaceous freshwater fish faunas in the world, especially with the fauna of China.

Materials and Methods

All fossil specimens used in the present study are deposited in the Kitakyushu Museum and Institute of Natural History.

Fossil specimens from the Wakino Subgroup are poorly preserved. All of their bones were eroded and in bad condition for observation.

Some specimens were immersed in a bath of 20% HCl and 80% water in 24–48 hours to etch their bones. This method was used by GRANDE (1987) and GRANDE and LUNDBERG (1988) for Siluriform fish from Wyoming and was effective for some specimens. Latex peels were made from the etched fossils for observation.

The outline of large specimens was drawn by tracing the enlarged positive films and detailed drawings were made with a binocular microscope. Drawings of small specimens and parts of specimens were made with a binocular dissecting microscope (Wild M-8). Restoration of the skeleton was made on the basis of the whole body figure of the holotype and added characters of the paratypes.

The number of vertebrae was counted from the foremost vertebra articulating with the cranium to the first preural centrum. Since the foremost vertebra was not visible in many specimens, the number of abdominal vertebrae was estimated with the number of ribs adding two. The number of caudal vertebrae was counted from the vertebra of the first haemal spine to the first preural centrum. If the first haemal spine was not clear, the number was counted from the vertebrae of the haemal spine in front of the first anal pterygiophore to the first preural centrum.

For the numbers of dorsal and anal fins, principal rays were counted. The number of branched rays and one unbranched ray of each lobe was counted for caudal fin rays.

The standard length of the specimens was taken from the tip of the snout (premaxilla) to the posterior margin of the hypural. The body depth was measured at the greatest dimension of the body. The head length was taken from the tip of the snout to the posterior margin of the opercle. If the opercle was not preserved, it was taken from the tip of the snout to the anterior margin of the middle of the cleithrum. The base of the dorsal and anal fins was measured from the anterior tip of the foremost ray to the posterior tip of the last pterygiophore.

Abbreviations

KMNH VP—Kitakyushu Museum and Institute of Natural History, Department of Vertebrate Paleontology.

Abbreviations used in text-figures.

A anal fin
ANG angulo-articular (retroarticular)
BRA branchiostegal
CHY ceratohyal

CLE	cleithrum
CRA	coracoid
CS	caudal scale
CV	caudal vertebra
D	dorsal fin
DEN	dentary
DS	dorsal scute
ECP	ectopterygoid
ENP	endopterygoid
EPU	epural
EXT2	extrascapular 2
FRO	frontal
G	gular plate
hs	haemal spine
HYO	hyomandibular
HYU	hypural
ifc	infraorbital sensory canal
IFO	infraorbital
ifoc	infraorbital canal
INO	interopercle
lc	cephalic division of main lateral line
MAX	maxilla
MET	metapterygoid
ns	neural spine
OPE	opercle
P_1	pectoral fin
P_2	pelvic fin
PAL	palatine
PARA	parasphenoid
PARH	parhypural
PARI	parietal
PREM	premaxilla
PREO	preopercle
PT	posttemporal
PTP1	first proximal pterygiophore
PU1	first preural vertebra
QUA	quadrate
SAG	sagitta
SANG	supraangular
SN	supraneural
SUPM	supramaxilla

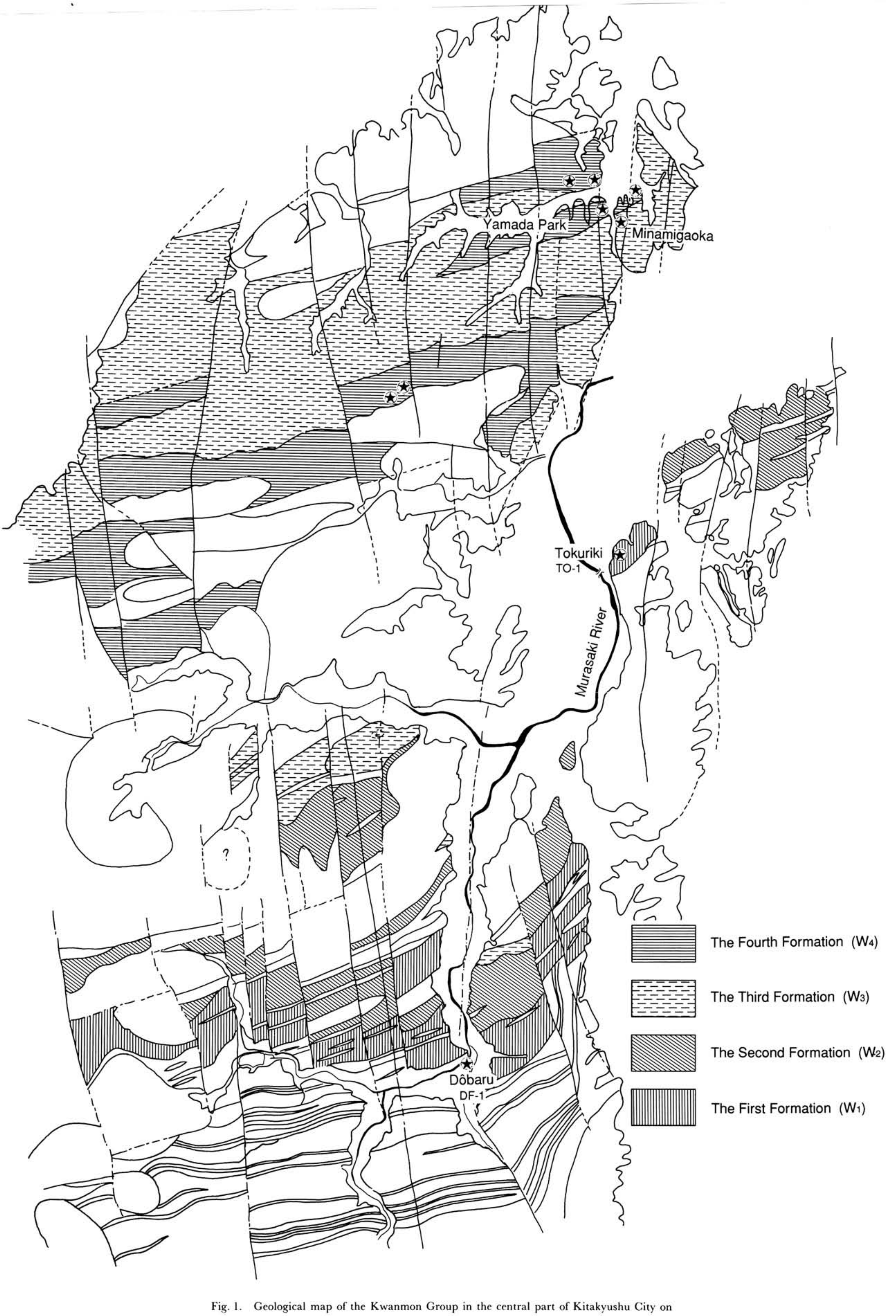

Fig. 1. Geological map of the Kwanmon Group in the central part of Kitakyushu City on the basis of Y. OTA (1955, 1957) and M. OTA *et al.* (1979). Stars in circles indicate fish fossil localities.

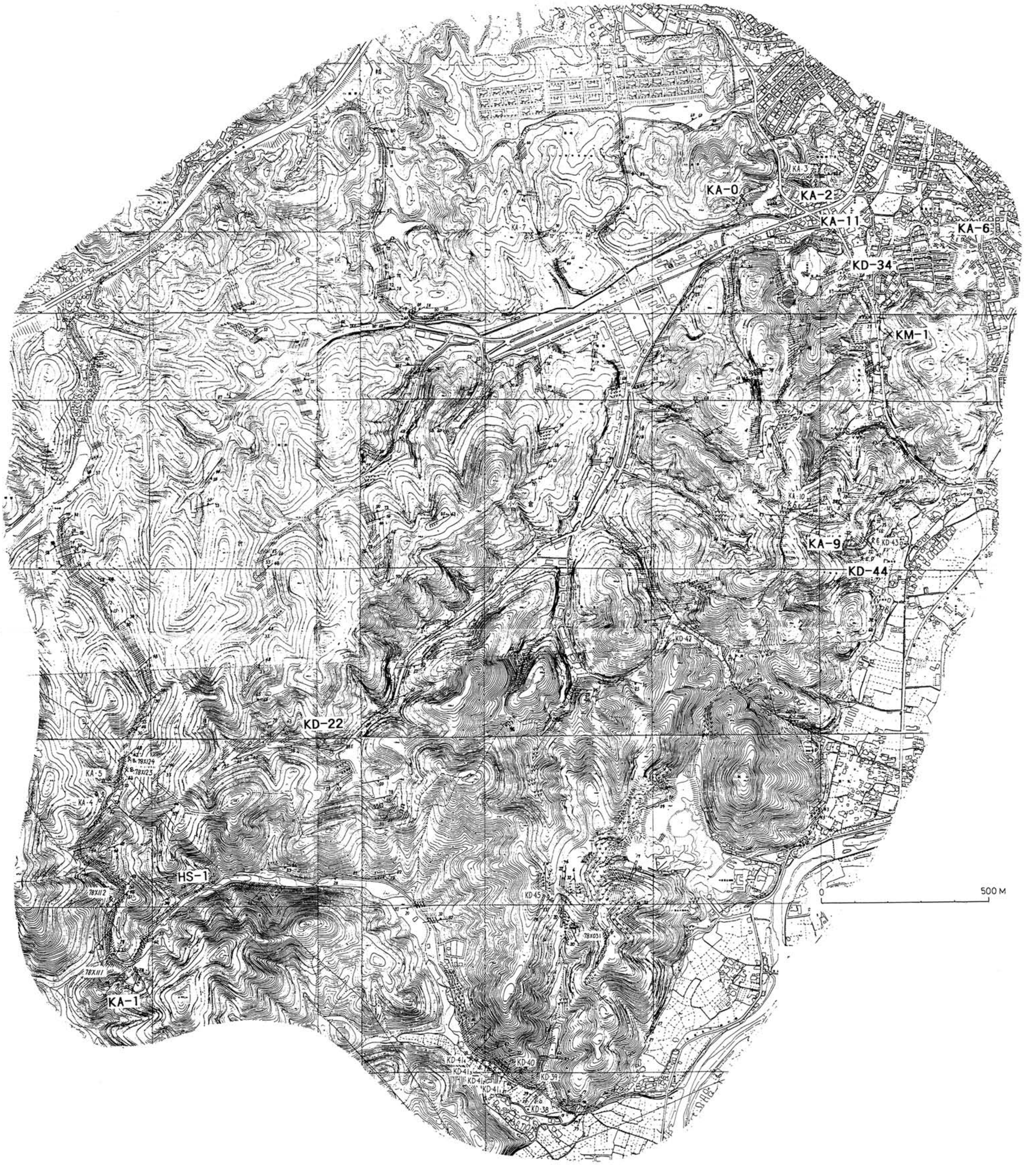

Fig. 2. Route map of Yamada Park, a former military arsenal and its surroundings (from M. Ota *et al.*, 1979) with the addition of two fish fossil localities (KM-1 and HS-1).

U1	first ural centrum
U1a	anterior part of first ural centrum
U1p	posterior part of first ural centrum
U2	second ural centrum
URN	uroneural
VS	ventral scute

Locality and Horizon

The Wakino Subgroup is distributed from the northern part of Kyushu Island to west of Yamaguchi Prefecture. Fish fossil sites of the Wakino Subgroup are restricted to Kitakyushu City, Fukuoka Prefecture (Fig. 1). There are 12 localities of fish fossils.

Two localities belonging to the First Formation (the lower formation, W_1) are found in Kokura-minami-ku (Kokura Southern Ward), Tokuriki and Dôbaru. Fish fossils are more abundant at Tokuriki (130°52′02″E, 33°49′115″N; locality no. TO-1). Some fish fossils are found at Dôbaru (130°51′00″E, 33°46′33″N; locality no. DF-1).

The only locality belonging to the Third Formation (the upper formation, W_3) is at Minamigaoka (130°51′02″E, 33°50′57″N; locality no. KM-1) in Kokura-kita-ku (Kokura Northern Ward).

There are 9 localities belonging to the Fourth Formation (the uppermost formation, W_4) which are situated in Yamada Park, a former military arsenal and in surrounding areas (Figs. 1 and 2). Among the localities, fish fossils are most abundant on the cliff near the front gate of Yamada Park (130°51′46″E, 33°51′11″N; locality no. KA-0 by M. OTA *et al.*, 1979) and on the cliff at the cement plant of Mitsubishi Material Co. Ltd. (130°51′58″E, 33°51′02″N; locality no. KD- 34 by M. OTA *et al.*, 1979). Some fish fossils were found in localities KA-1, KA-2, KA-6, KA-9, KA-11, KD-22, (M. OTA *et al.*, 1979) and Sanji (130°50′35″E, 33°50′00″N; locality no. HS-1). Locality KA-0 belongs to the lower part of the Fourth Formation and the locality of KA-1 belongs to the upper part of the Fourth Formation (M. OTA *et al.*, 1979).

Y. OTA (1955, 1957) recognized four formations in the Wakino Subgroup in Kitakyushu City: the lower formation, the middle formation, the upper formation and the uppermost formation (Fig. 3). These formations were correlated respectively, to the four formations of the Wakino Subgroup in Wakino: the Sengoku Formation, the Nyoraida Formation, the Lower Wakamiya Formation and the Upper Wakamiya Formation (Y. OTA, 1955, 1960b). The age of the Sengoku Formation is considered to be Hauterivian to Barremian (Y. OTA, 1981). The age of the Wakino Subgroup is considered to be Late Neocomian (Y. OTA, 1981; MATSUMOTO *et al.*, 1982).

Four formations in this area are described here on the basis of Y. OTA (1955, 1957), MATSUSHITA (1968), and M. OTA *et al.* (1979). Several names for each

	Y. OTA, 1953	Y. OTA, 1955; 1957	Y. OTA, 1960	HASE, 1958; 1960	MATSUSHITA, 1968	M. OTA *et al.*, 1979
District	Wakino (Type locality)	Kokura and Yahata	North Kyushu and West Yamaguchi Prefecture	Kokura, Yahata, Tobata and Wakamatsu	Kitakyushu City	Kokura
Wakino Subgroup	Upper Wakamiya formation	Uppermost formation	W_4	? Equivalent of the Upper Wakamiya formation	The Fourth Formation	The Fourth Formation
	Lower Wakamiya formation	Upper formation	W_3	Equivalent of the Lower Wakamiya formation	The Third Formation	The Third Formation
	Nyoraida formation	Middle formation	W_2	Equivalent of the Nyoraida formation	The Second Formation	The Second Formation
	Sengoku formation	Lower formation	W_1	Equivalent of the Sengoku formation	The First Formation	The First Formation

Fig. 3. Correlation of the formations in the Wakino Subgroup of the Kwanmon Group.

formation in this area have been used as follows: the Lower formation, the Middle formation, the Upper formation and the Upper-most (and Uppermost) formation (Y. OTA, 1957, 1960), W_1, W_2, W_3 and W_4 (Y. OTA, 1960), Equivalent of the Upper Wakamiya formation, Equivalent of the Lower Wakamiya formation, Equivalent of the Nyoraida formation and Equivalent of the Sengoku formation (HASE, 1958, 1960), and the First Formation, the Second Formation, the Third Formation and the Fourth Formation (MATSUSHITA, 1968; M. OTA *et al.*, 1979) in ascending order (Fig. 3).

In this study the author tentatively adopts the local stratigraphic divisions proposed by MATSUSHITA (1968) for the Kitakyushu area.

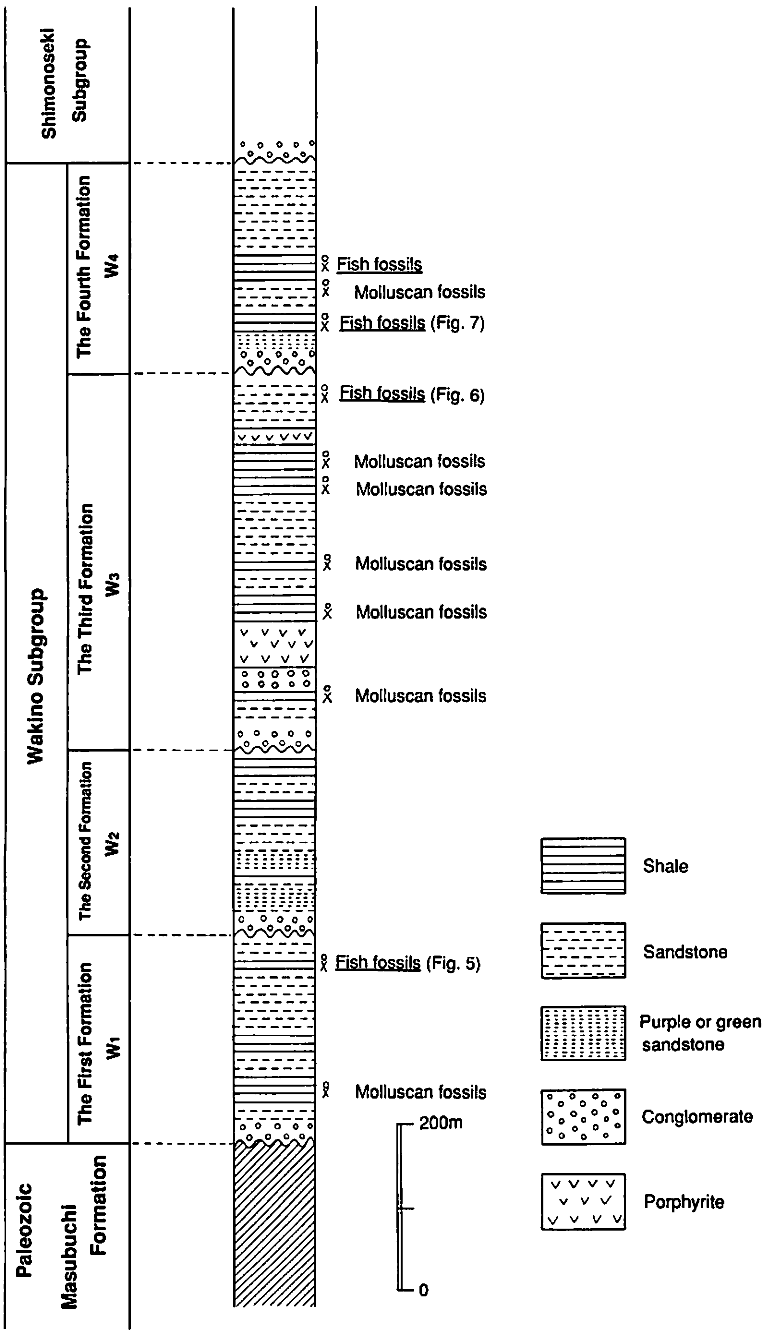

Fig. 4. Stratigraphic section of the Wakino Subgroup in Kitakyushu City on the basis of Y. OTA (1955, 1957, 1960) and M. OTA *et al.* (1979).

The First Formation (the lower formation, W_1) correlates to the Sengoku Formation. This formation is distributed along the Murasaki River in Kokura-minami-ku. The thickness is 200–280 m. The basal part consists of a conglomerate of limestone, chert and others. The conglomerate involves large pebbles. There is a limestone conglomerate about 50 m from the base. Most conglomerates are breccia and the pebbles are small in size. The main part is composed of abundant conglomerate and green-gray sandstone in the area along the Murasaki River. The

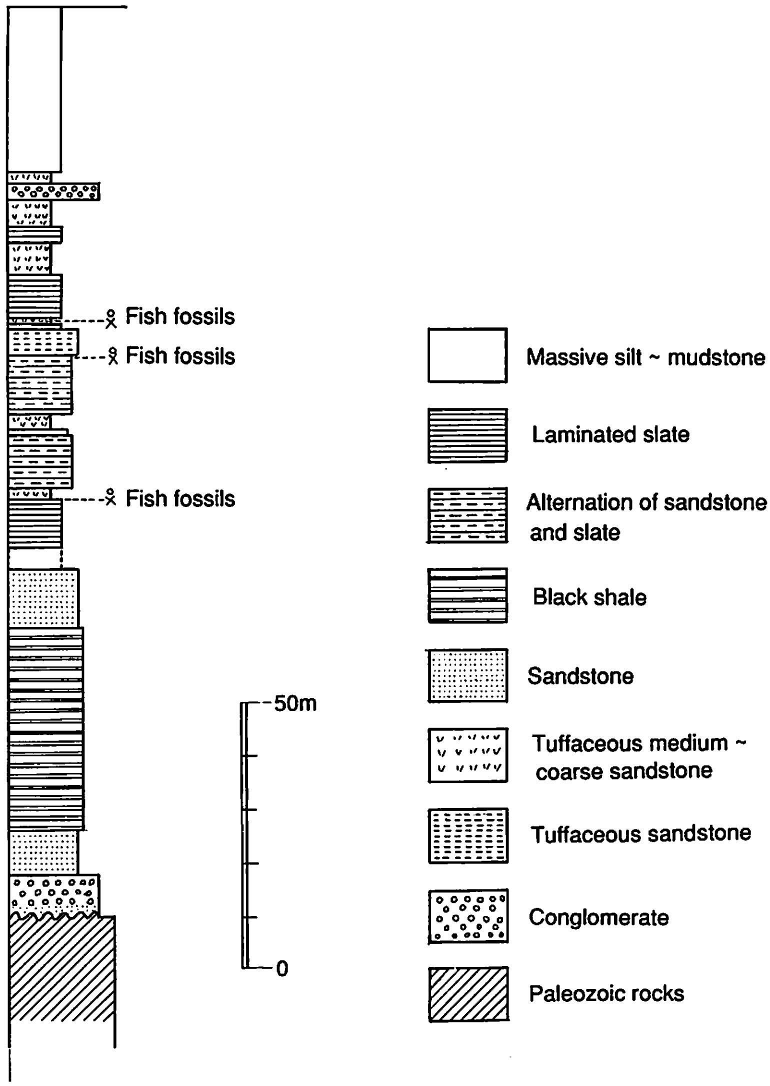

Fig. 5. Columnar section at Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City.

upper part consists of alternating black sandstone and black sandy shale along the Murasaki River (Fig. 4). At Tokuriki, the basal part directly overlies Paleozoic rocks with remarkable clinounconformity and the main part is composed of alternating sandstone, conglomerate and black shale. The upper part is composed of abundant sandstone, yellowish-brown on weathered surface, with thin black shale and the upper end of the formation is unknown at Tokuriki. The molluscan fossil *Brotiopsis wakinoensis* is abundant and *Plicatounio naktongensis naktongensis* is common. Fish fossils are found in green-gray shale and yellowish-gray shale of three horizons in the main part at Tokuriki (Fig. 5). Plant and molluscan fossils are found in the lowest horizon of fish fossils. There is a conglomerate above the horizons of fish fossils and tuffaceous sandstone becomes abundant above the conglomerate.

The Second Formation (the middle formation, W_2) correlates to the Nyoraida Formation. This formation is distributed west of Ishida and along the Murasaki River. The thickness is 250–320 m. The conglomerate, 3 m in thickness at the base of the formation conformably overlies the black shale of the top of the lower formation at the bottom of the Murasaki River near Kawarabashi Bridge. The Second Formation unconformably directly overlies Paleozoic rocks west of Ishida. The Second Formation is characterized by abundant pyroclastic rock, green-gray calcareous fine sandstone, and intercalating, nodule-bearing and thin siliceous shale (Fig. 4). Molluscan fossils of *Brotiopsis kobayashii, Viviparus onogoensis* and *Sphaerium* (?) sp., and Ostracoda were found at Takatsuo in Kokura-minami-ku (Y. Ota and Yabumoto, 1992). No fish fossils have been found in the Second Formation.

The Third Formation (the upper formation, W_3) correlates to the Lower Wakamiya Formation. This formation is mainly distributed in and around Yamada Park, the former military arsenal, and is distributed in the limited area along the Murasaki River and its branch, the Oma River. The thickness is about 350–450 m. It is composed mainly of sandstone, with alternating sandstone and shale, siliceous shale, tuff and others (Fig. 4). Fish fossils are found in the well-laminated yellowish-white and reddish-brown slate at Minamigaoka (Fig. 6). Molluscan fossils, *Viviparus onogoensis* and *Nakamuranaia* (?) sp. cf. *N. chingshanensis* are abundant and *Brotiopsis kobayashii* are present. Conchostracan and plant fossils are found together with numerous Ostracoda yielded with fish fossils.

The Fourth Formation (the uppermost formation, W_4) correlates to the Upper Wakamiya Formation. This formation is widely distributed in and around Yamada Park. The thickness is some 250 m. The basal part consists of a conglomerate of white chert and unconformably or conformably overlies the Third Formation. The Fourth Formation is composed chiefly of sandstone and siliceous shale, with shale, tuff, conglomerate and reddish purple sandstone (Fig. 4). Molluscan fossils of *Viviparus onogoensis* and *Brotiopsis* sp., gastropods, Ostracoda, conchostracan, and plant fossils are found in the Fourth Formation. Fish fossils are abundant in this formation (Fig. 7).

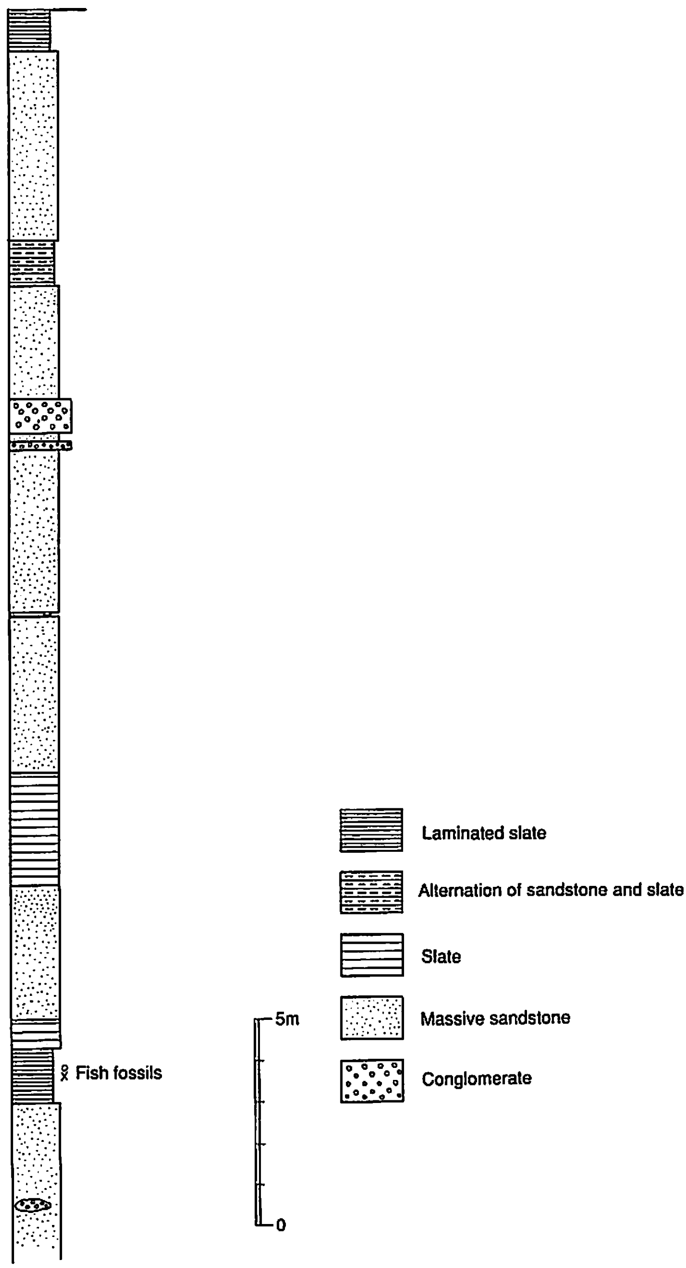

Fig. 6. Columnar section at Minamigaoka (KM-1), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City.

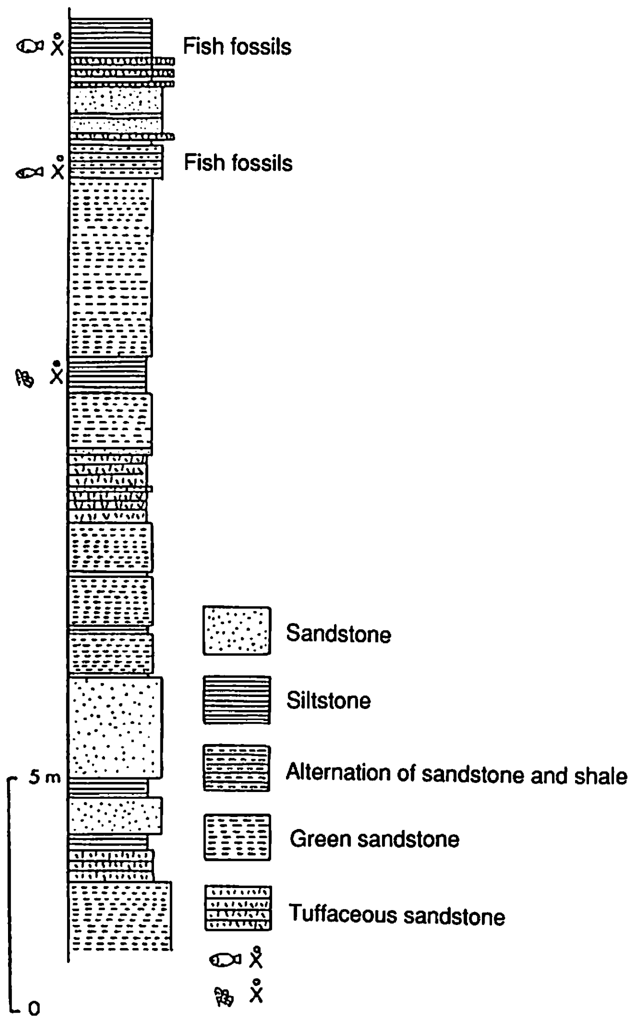

Fig. 7. Columnar section at Kumagai (KA-0), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City. From M. OTA *et al.*, 1979.

Systematic Paleontology

Class Osteichthyes
Subclass Actinopterygii
Infraclass Neopterygii
Division Halecostomi
Order Semionotiformes
Family Semionotidae

Genus *Lepidotes* AGASSIZ, 1832

Diagnosis. It differs from the other genus, *Semionotus,* in having the combination of following characters. A median vomer and tritoral dentition are present. Two or more anamestic suborbitals are present (SCHAEFFER and DUNKLE, 1950; McCUNE, 1986; OLSEN and McCUNE, 1991). The fossils are found from the Upper Triassic into the Cretaceous in Europe, North America, South America, Asia, Africa and Madagascar.

Type species. *Lepidotes gigas* AGASSIZ, 1832.

Lepidotes macropterus sp. nov.

(Pl. 36)

Diagnosis. It differs from other species of the genus *Lepidotes* in having the combination of following characters. The dorsal fin is situated at about the middle of the body. The dorsal fin base is long and its length is contained 1.4 times in the body depth. The pelvic fin is below the dorsal fin. The number of dorsal fin rays is 13 with 4 fin fulcra. The number of scales from the dorsal margin to the ventral margin at the caudal immediately behind the dorsal fin is 11 to 13.

Holotype. KMNH VP 100,146, the middle part of the body. The anterior part and the posterior part of the body are missing. The length of the preserved portion is 78.0 mm along the body axis.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The speciese name, *macropterus,* means a long or large fin, which refers to the fact that this species has the long dorsal fin base.

Description of the holotype.

The presumed body depth is moderate. The dorsal fin is situated at about the middle of the body. The dorsal fin base is long and its length is contained 1.4 times in the body depth. There are 14 dorsal fin rays with 4 fin fulcra. The first fin fulcrum of the dorsal fin is short and its length is about one third of the second fin fulcrum. The second fin fulcrum is about half of the third fin fulcrum. The third fin fulcrum is about one third of the fourth fin fulcrum. The scales of caudal part of the body are rhombic. The number of scales from the dorsal margin to the ventral margin at the caudal immediately behind the dorsal fin is 11 to 13.

Remarks. The family Semionotidae of the order Semionotiformes has two genera, *Semionotus* and *Lepidotes,* and the Semionotidae share the presence of dorsal ridge scales and a large posteriorly directed process on the epiotic (OLSEN and McCUNE, 1991). The presence of dorsal ridge scales and a large posteriorly directed process on the epiotic are unknown, but the present fossil is similar to *Lepidotes yungkangensis* (CHANG & CHOU, 1974) from Early Cretaceous deposits of Zhejiang Province in China in the position of the dorsal and pelvic fins, the number and the form of fin fulcra of the dorsal fin, the form of scales and the number of scales from the dorsal margin to the ventral margin at the caudal immediately behind the dorsal fin. But *L. macropterus* differs from *L. yungkangensis* in the number of dorsal fin rays and the length of the dorsal fin base. The number of dorsal fin rays is 14 in *L. macropterus,* 9 in *L. yungkangensis.* The length of the dorsal fin base is contained 1.4 times in the body depth in *L. macropterus,* 3.0 times in *L. yungkangensis.*

Subdivision Halecomorphi
Order Amiiformes
Family Amiidae
Genus ***Nipponamia* gen. nov.**

Diagnosis. It differs from other genera of the Amiidae in having the combination of following characters. The gular plate is almost rhombic in the ventral view. The premaxillary teeth are larger than teeth on the dentary and the number of teeth is 4. The margin between the condyles of the hyomandibular for the neurocranium and the opercular process is narrow and deeply concave in V-shape. The ventral end of the hyomandibular is divided into two parts. The number of vertebrae is numerous and 75 including ural centra. The length of vertebral centra is shorter than the depth. The ural centra are slightly curved upward. Ganoid scales are absent.

Type species. *Nipponamia satoi* sp. nov.

Etymology. The generic name, *Nipponamia* consists of *Nippon* meaning Japan, and

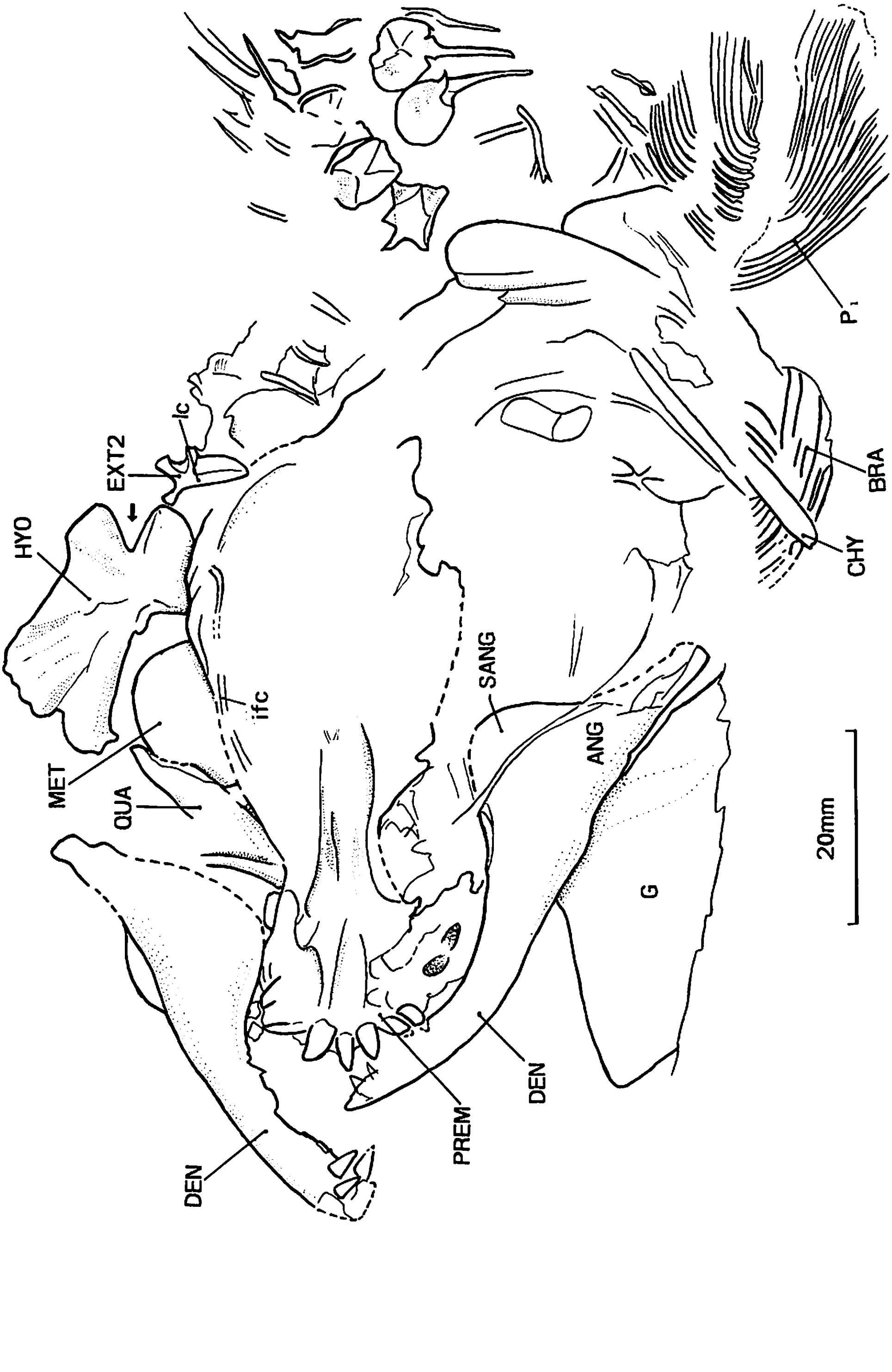

Fig. 8. *Nipponamia satoi* gen. et sp. nov., head region of the holotype, KMNH VP 100,147. An arrow indicates the margin between the condyles of the hyomandibular for the neurocanium and the opercular process.

Table 1. Comparison of characters in three genera of the family Amiidae from China and Japan.

	Nipponamia gen. nov.	*Sinamia*	*Ikechaoamia*
TL	301.0 mm	120–270 mm	94 mm
counts			
Premaxillary teeth	4	6–11	5 or more
Vertebrae	74	?	45–50
other characters			
Gular plate	rhombic	triangle	?
Largest teeth	on premaxilla	almost similar in size	on dentary
Hyomandibular*	deeply concave in V-shape	wide and shallow	?
Ventral end of hyomandibular	two parts	one part	?
Length of vertebral centrum	shorter than the depth	longer than the depth	longer than the depth
Ural centrum	slightly curved	curved	curved
Ganoine scale	absent	present	present

* The part between the condyles of hyomandibular for the neurocranium and the opercular process. TL, total length.

amia, a generic name of the family Amiidae.

Nipponamia satoi sp. nov.

(Figs. 8–11, Pl. 37–38)

Diagnosis. As for the genus, monotypic species.

Holotype. KMNH VP 100,147, the dorsal surface of the head region and the lateral side of the body are exposed, but most of the dorsal fin, pelvic fin and anal fin are missing. The total length is 298.0 mm.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species is named for Mr. Masahiro Sato who collected and donated the specimen to the Kitakyushu Museum and Institute of Natural History.

Description of the holotype.

The body and the head region appear to be cylindrical, assuming from the

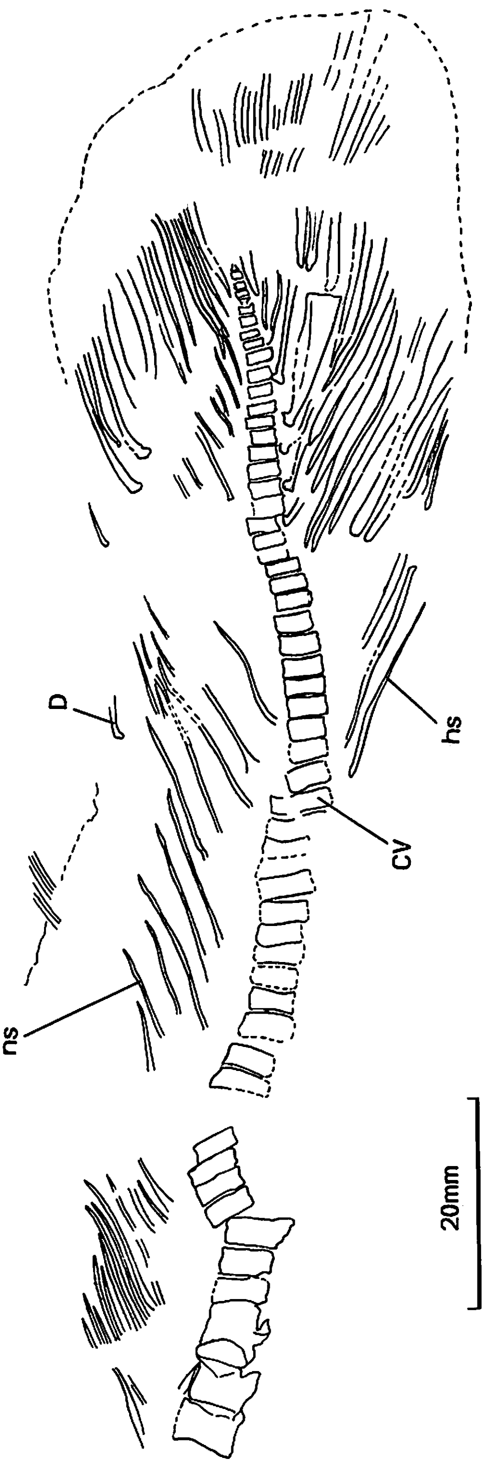

Fig. 9. *Nipponamia satoi* gen. et sp. nov., caudal region of the holotype, KMNH VP 100,147.

Fig. 10. *Nipponamia satoi* gen. et sp. nov., the holotype, KMNH VP 100,147. Two arrows indicate the origin and the posterior end of the dorsal fin base.

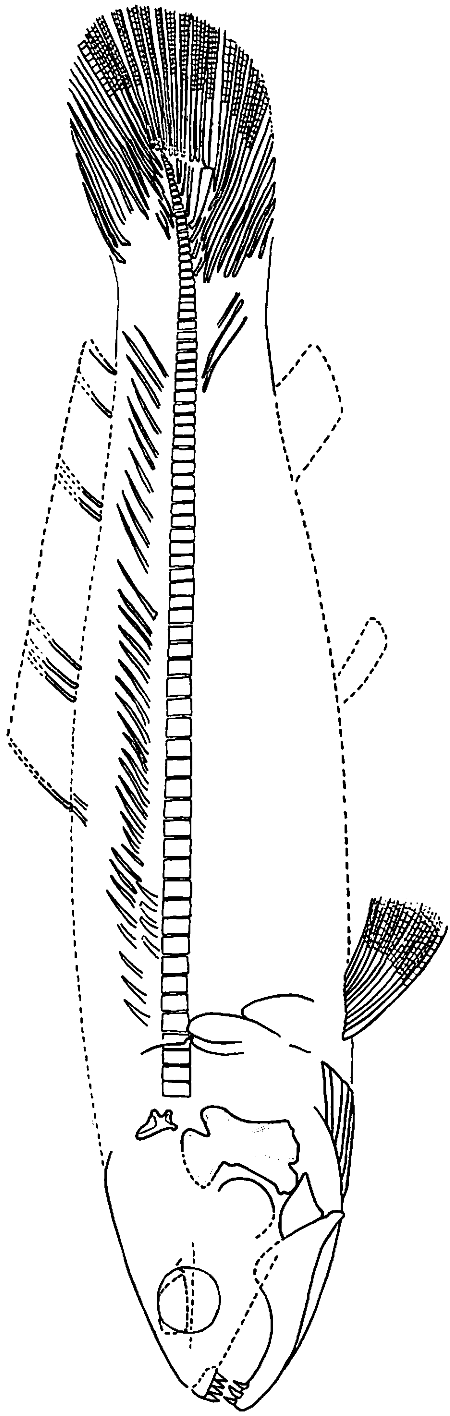

Fig. 11. *Nipponamia satoi* gen. et sp. nov., restoration of preserved parts of the skeleton.

exposed dorsal surface of the head region. The premaxilla is attached to the neurocranium having 4 large canine like teeth.

The lower jaw is narrow at the anterior half and the depth rapidly increase at the posterior one third. Three canine like teeth are visible on the anterior part of the dentary. The premaxillary teeth are larger than the dentary teeth. A boundary line between the dentary, anglo-articular and supraangular is indistinct. A suture of each bone on the neurocranium is obscure. The interorbital space is narrow. About half of the gular plate is preserved and the whole shape can be restored. The gular plate is nearly rhombic in ventral view (Fig. 8).

The right hyomandibular is preserved. The part between the condyle of hyomandibular for the neurocranium and the opercular process is narrow and deeply concave in V-shape. The ventral end of the hyomandibular is divided into two parts. The metapterygoid is thin and rounded at the lower part. The upper part of the metapterygoid is not visible, because it is under the neurocranium. The quadrate is thick. The second extrascapular is long with the cephalic division of main lateral line. The ceratohyal is long and cylindrical with 8 or more branchiostegals. The shoulder girdle is obscure. A pair of pectoral fins are preserved and have 11 or 12 fin rays respectively.

Most part of the dorsal fin is missing, but the anterior and the posterior end is definable (Fig. 10). The dorsal fin base is long. The dorsal origin is above the 16th vertebra and the end of dorsal fin base is above the 45th vertebra (Fig. 10). The caudal fin is rounded. The total number of the centrum (include ural centrum) is 75. The neural and haemal spines of the caudal vertebrae are alternately present. The length of vertebral centra is shorter than the depth. The ural centra are slightly curved upward (Fig. 9).

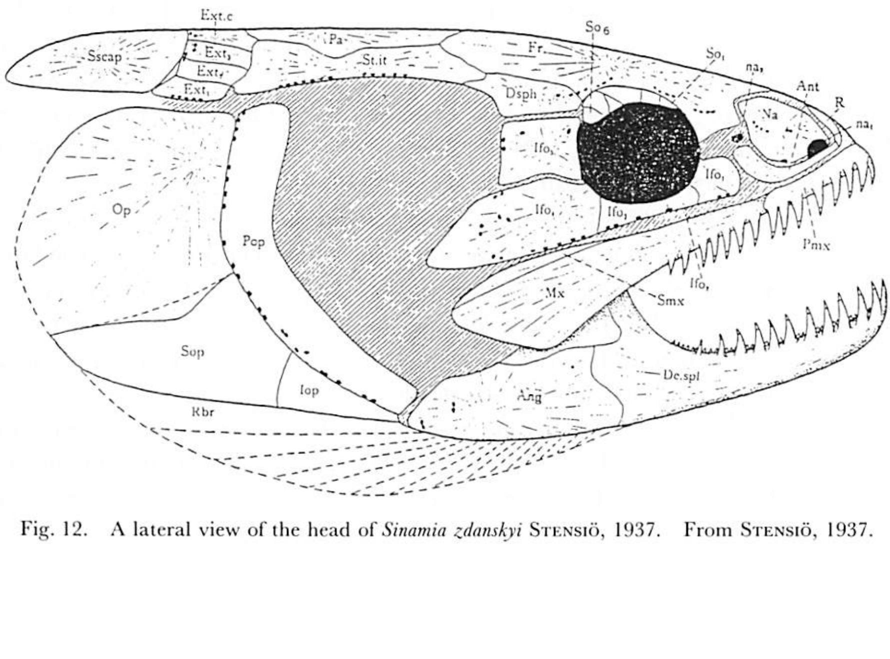

Fig. 12. A lateral view of the head of *Sinamia zdanskyi* STENSIÖ, 1937. From STENSIÖ, 1937.

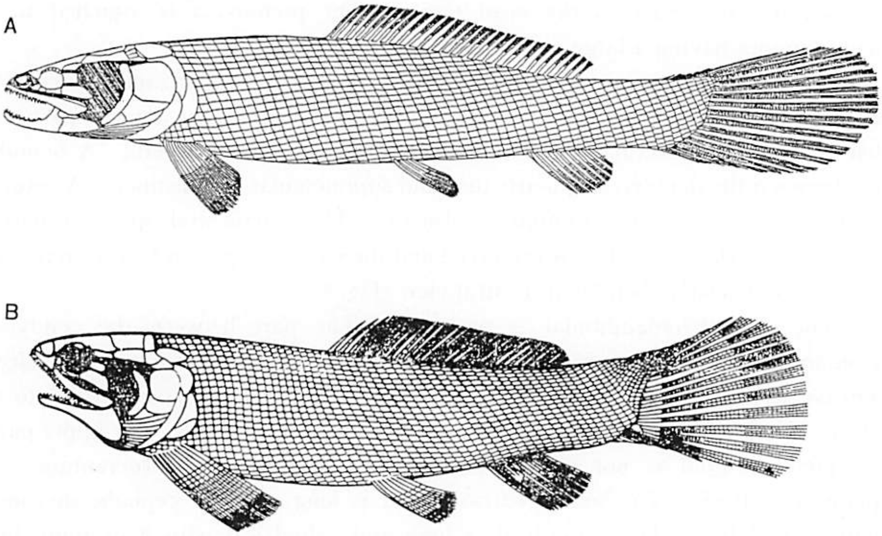

Fig. 13. A, the restoration of *Sinamia zdanskyi* STENSIÖ, 1937. From LIU *et al.*, 1963. B, the restoration of *S. poyangica* SU & LI, 1990, from SU and LI, 1990.

Remarks. Although the present fossil is not complete, and the pelvic fin and the anal fin are missing, it clearly shows characters to be a member of the family Amiidae of the order Amiiformes: the premaxilla attached to the neurocranium, the shape of the mandible as in Fig. 4, large teeth present on the premaxilla and the dentary (Fig. 8), the neural and haemal spines present alternately on the caudal vertebrae (Fig. 9).

The family Amiidae contains about 10 genera from Upper Jurassic to Recent in North America, South America, Europe, Africa and Asia (PATTERSON, 1973; BORESKE, 1974; CHALIFA and TCHERNOV, 1982; WILSON, 1982). Among them, *Nipponamia* is closer to genera from China, *Sinamia* and *Ikechaoamia* from Nei Mongol, Zhejiang, Jiangxi, Jilin, and Ninghsia (STENSIÖ, 1935; LIU, 1961; LIU *et al.*, 1963; ZHANG and ZHANG, 1980; LI, 1984; SU and LI, 1990) in the shape of mandible, the long dorsal fin base and elongate body (Figs. 12–15).

But *Nipponamia* differs from *Sinamia* and *Ikechaoamia* with the diagnostic characters described above. The gular plate is triangle in *Sinamia* (Fig. 14). The largest teeth are on the dentary in *Ikechaoamia* (Fig. 15). The size of teeth on jaws are similar in *Sinamia* (Fig. 12). The number of premaxillary teeth is over 4 in *Ikechaoamia*. The margin between the condyles of the hyomandibular for the neurocranium and the opercular process is wide and shallow in *Sinamia*. The ventral end of the hyomandibular is not divided in *Sinamia* (Fig. 16). The number of vertebrae is up to 50 in *Ikechaoamia*. The length of vertebral centra is longer than the depth in *Sinamia* and *Ikechaoamia*. The scales are rhombic with ganoin layer in *Sinamia* and *Ikechaoamia* (Tab. 1).

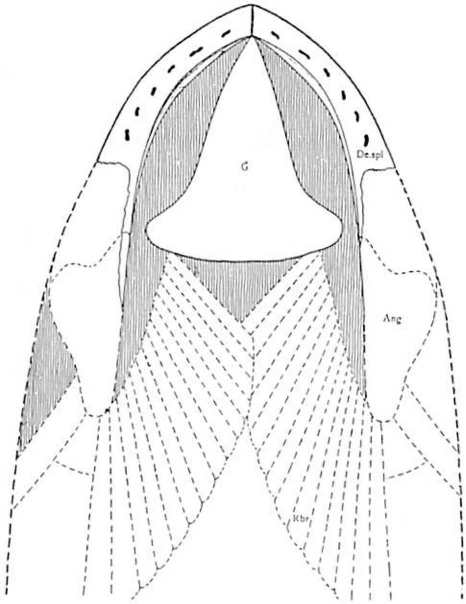

Fig. 14. A ventaral view of the head region of *Sinamia zdanskyi* STENSIÖ, 1937. From STENSIÖ, 1937.

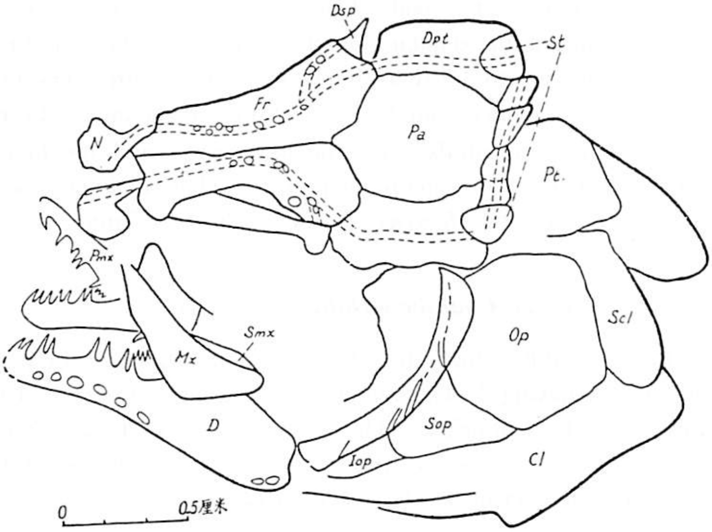

Fig. 15. A lateral view of the head of *Ikechaoamia meridionalis* ZHANG & ZHANG, 1980. From ZHANG and ZHANG, 1980.

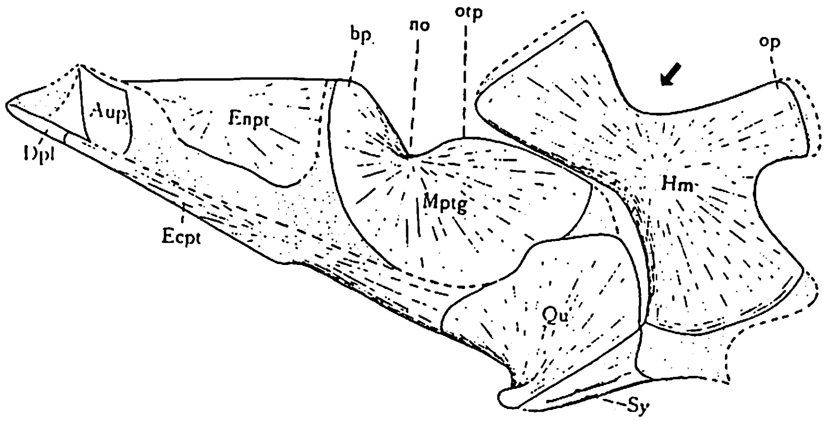

Fig. 16. The suspensorium of *Sinamia zdanskyi* STENSIÖ, 1937. From STENSIÖ, 1937. An arrow indicates the part between the condyles of the hyomandibular for the neurocanium and the opercular process.

Subdivision Teleostei
Order Ichthyodectiformes
Family Chuhsiungichthiidae nov.

Diagnosis. It differs from other families of the Ichthyodectiformes in the combination of following characters. The body depth is moderate. The body depth is contained 2.3 to 3.7 times in the standard length. The head is large and the length of the head is contained 2.9 to 4.0 times in the standard length. The number of dorsal fin 14 to 25. The number of anal fin is 32 to 46. The number of vertebrae is 40 to 54. The anterior uroneurals cover the ural centra and the first preural centrum. The median fins are posterior in position. The anal fin base is long. Two genera, *Chuhsiungichthys* and *Mesoclupea,* belong to this new family.

Genus ***Chuhsiungichthys*** LEW, 1974

Diagnosis. This genus differs from the other genus, *Mesoclupea,* of the new family Chuhsiungichthiidae in having the combination of following characters. The dorsal origin is slightly before the anal origin. The dorsal fin base is relatively long and its length is contained 1.4 to 1.9 times in the anal fin base. The number of dorsal fin rays is 20 to 25. The number of vertebrae is 40 to 42.

Type species. *Chuhsiungichthys tsanglingensis* LEW, 1974.

Remarks. The genus *Chuhsiungichthys* contains three species, *C. tsanglingensis* LEW,

1974 from Upper Cretaceous of Yunnan Province in China, *C. yanagidai* sp. nov. and *C. japonicus* sp. nov.

Chuhsiungichthys yanagidai sp. nov.

(Figs. 17–21, Pls. 39–40)

Diagnosis. This species differs from other species in having the combination of following characters. The dorsal fin is large and long. The dorsal origin is slightly before the anal origin. The length of the first dorsal fin ray is contained 4.7 times in the standard length. The length of the dorsal fin base is contained 1.4 times in the anal fin base. The number of dorsal fin rays is 20. The number of anal fin rays is 32 and this number is the smallest in this genus. The total number of vertebrae is 40 to 42, with 21 to 24 caudal vertebrae. The number of ribs is 17. The body depth is contained 3.6 times in the standard length. The head length is contained 4.0 times in the standard length.

Holotype. KMNH VP 100,148, an almost complete specimen, but the bones of the head region is poorly preserved and the anterior and posterior parts of the caudal vertebrae slightly are moved. The standard length is 168.2 mm.

Paratype. KMNH VP 100,149, an incomplete specimen, the dorsal part of the head is missing, anterior caudal vertebrae is detached. The standard length is 120.0 mm.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyu-

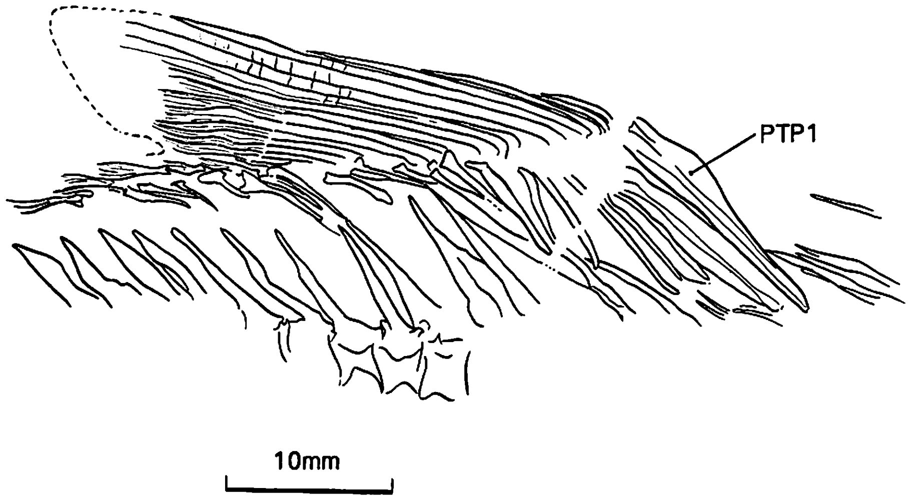

Fig. 17. *Chuhsiungichthys yanagidai* sp. nov., the dorsal fin of the holotype, KMNH VP 100,148.

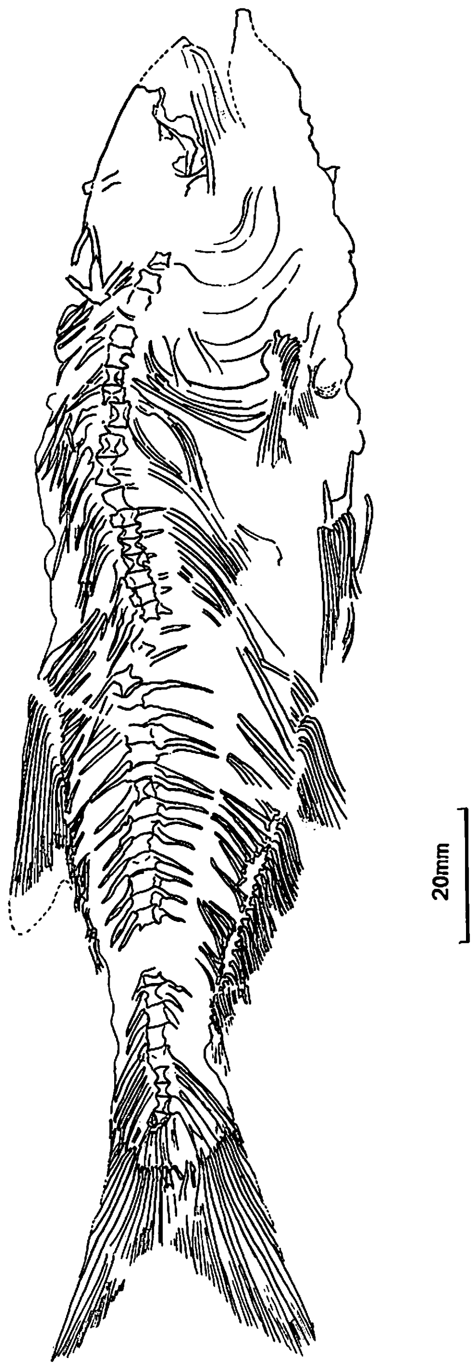

Fig. 18. *Chuhsiungichthys yanagidai* sp. nov., the holotype, KMNH VP 100,148.

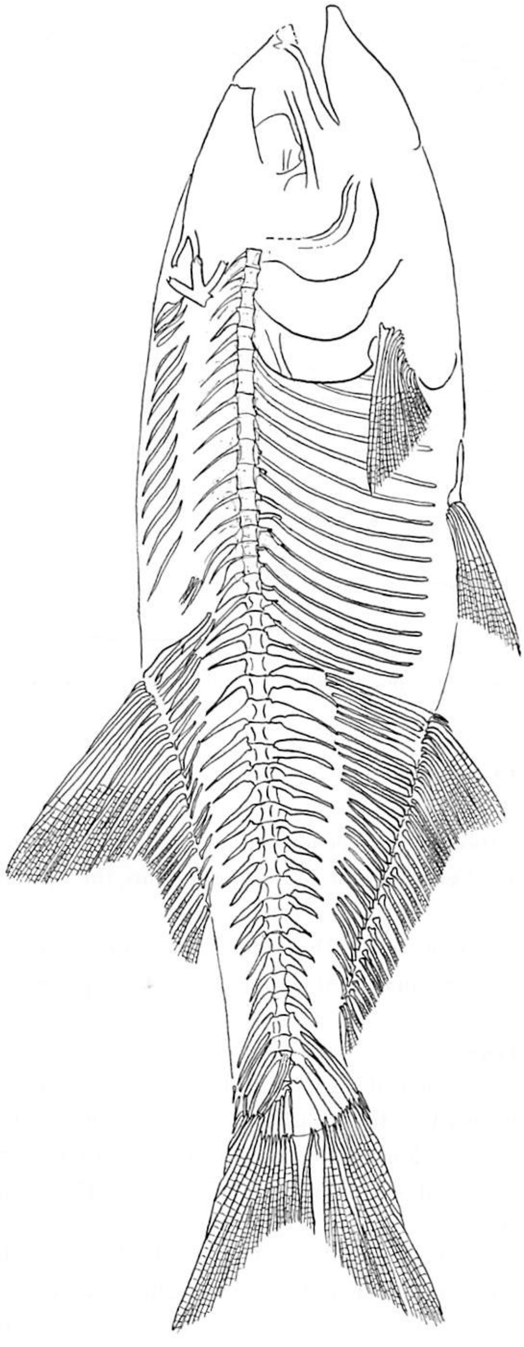

Fig. 19. *Chuhsiungichthys yanagidai* sp. nov., restoration of the skeleton.

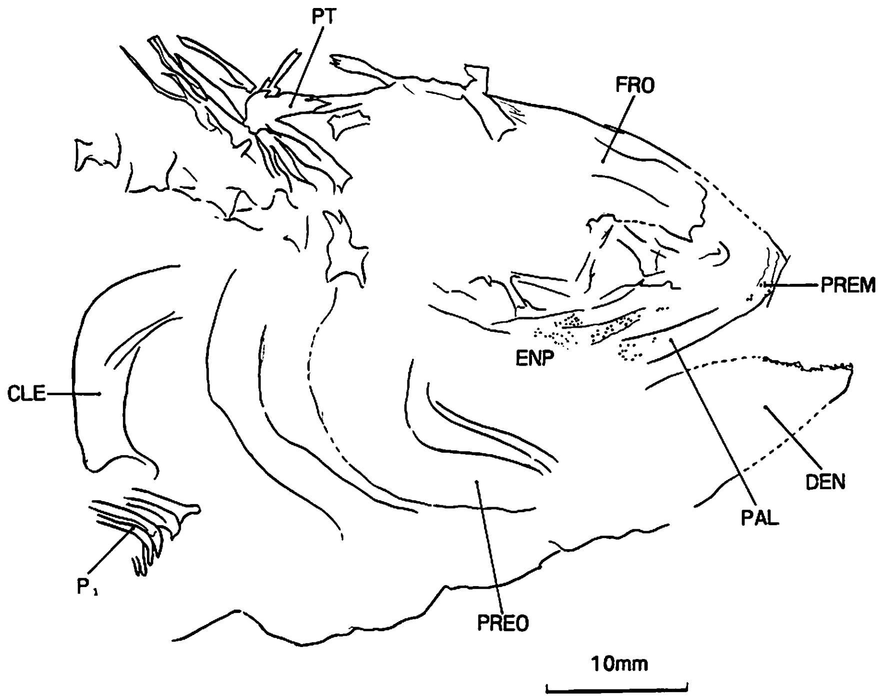

Fig. 20. *Chuhsiungichthys yanagidai* sp. nov., head region of the holotype, KMNH VP 100,148.

shu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species is named for Dr. Juichi YANAGIDA of the professor of Kyushu University, who gave me many valuable advice for the present study.

Description of the holotype.

The body is fusiform and laterally compressed. The body depth is contained 3.6 times in the standard length. The head length is contained 4.0 times in the standard length. The dorsal outline of the head region is entirely convex and the line from the head to the dorsal origin is equally convex. The median fins are relatively posterior in position.

The dorsal fin is large and long (Fig. 17). The length of the first dorsal fin ray is contained 4.7 times in the standard length. The length of the dorsal fin base is contained 1.4 times in the anal fin base. The dorsal origin is just before the anal origin. The first dorsal pterygiophore is above the neural spine of the 17th abdomi-

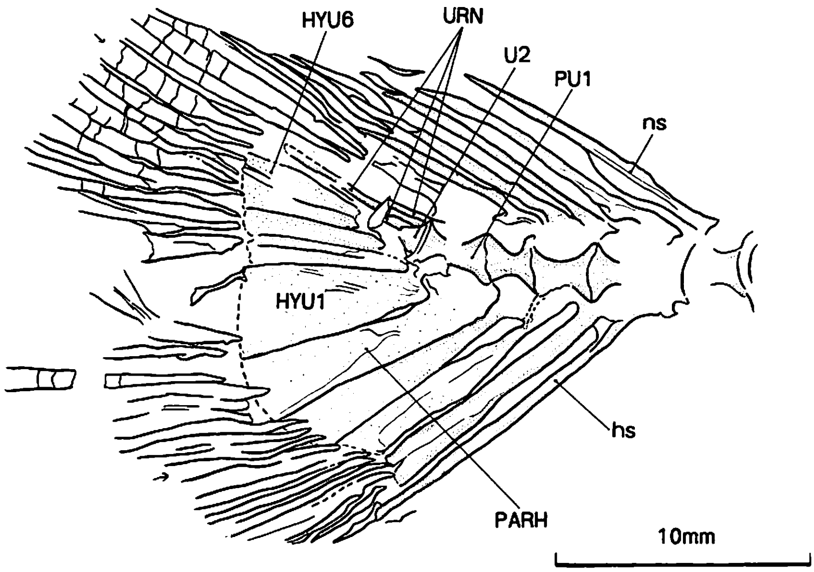

Fig. 21. *Chuhsiungichthys yanagidai* sp. nov., caudal skeleton of the holotype, KMNH VP 100,148.

nal vertebra. The end of the dorsal fin base is about vertical with posterior one third of the anal fin base. The number of principal dorsal fin rays is 20. There are 20 dorsal fin pterygiophores. The anal fin base is long. The length of anal fin base is about 1.3 times of the dorsal fin base. The number of principal anal fin rays is 31. There are 29 anal fin pterygiophores. The anal and dorsal fin rays are long at the anterior part and becomes rapidly shorter at the posterior part. This is remarkable in the dorsal fin. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively.

The pectoral fin does not elongate and reaches the pelvic insertion. The pelvic fin is present at the middle of the abdomen. The caudal fin is forked (Fig. 18). There are 19 principal caudal fin rays (1,9,8,1). The number of procurrent caudal fin rays is 8 in the upper lobe and 6 in the lower lobe (Fig. 21).

The orbital is relatively large. There are minute teeth on the dentary, premaxilla, endopterygoid and palatine. The teeth on the premaxilla, endopterygoid and palatine are villiform. The dentary bears minute canine like teeth on its oral margin. The suture between the dentary and angulo-articular is not visible. The posterior part of the mandible is poorly preserved (Fig. 20).

The total number of vertebrae is 40, with 21 caudal vertebrae. The ribs are slender and long. The estimated number of ribs is 17. There is a series of median supraneurals beginning close behind the head and ending above the 17th abdominal vertebra.

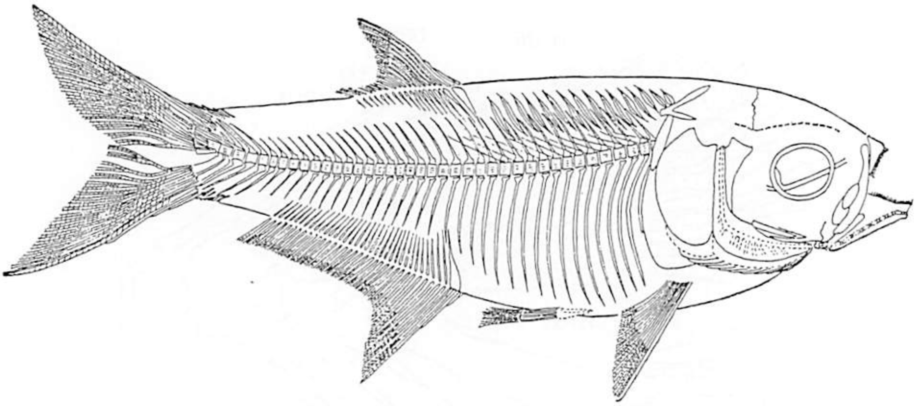

Fig. 22. The restoration of *Chuhsiungchthys tsanglingensis* LIU, 1974. From LIU, 1974.

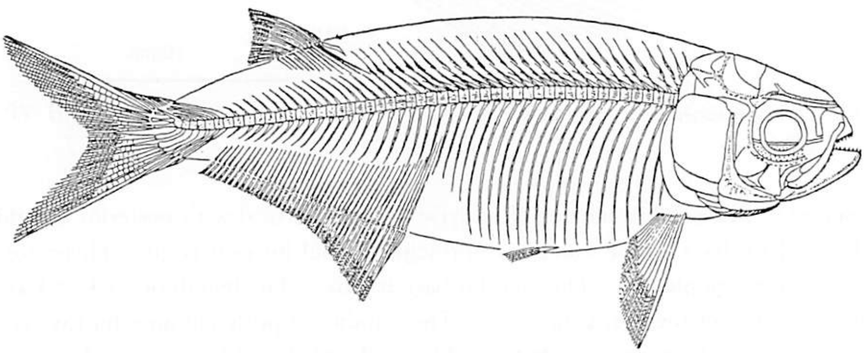

Fig. 23. The restoration of *Mesoclupea showchangensis* PING & YEN, 1933. From CHANG and CHOW, 1977.

There are 6 hypurals. The first hypural is the largest. The third to sixth hypurals are cylindrical. The first ural centrum is larger than the first preural centrum and bears two hypurals (HYU1 and HYU2). The second ural centrum is small and about half of the first preural centrum. Three uroneurals of the right side are visible. The anterior part of the uroneurals cover the ural centra and the first preural centrum (Fig. 21).

Description of the paratype.

The number of dorsal fin rays is 21. The number of anal fin rays is 33. The number of anal fin pterygiophores is 32. The number of pelvic fin rays is 18. The total number of vertebrae is approximately 42, with 24 caudal vertebrae.

Table 2. Comparison of characters in the species of the family Chuhsiungichthyiidae nov.

	Chuhsiungichthys yanagidai sp. nov.	*C. japonicus* sp. nov.	*C. tsanglingensis*	*Mesoclupea showchangensis*
SL	168.2 mm	217.0–220.0 mm	50–140 mm	40–170 mm
counts				
D.	20–21	21	21–23	14
A.	32	39	39–40	46
P_1	14+	18	15	12
Vertebrae	40	—	40–42	53–54
ratio				
SL/BD	3.6	2.4–2.5	3.0–3.7	2.7–3.4
SL/HL	4	—	2.9	3.8
AB/DB	1.4	1.6	1.9	4.2

A., anal fin rays; AB, anal fin base; BD, body depth; D., dorsal fin rays; DB, dorsl fin base; HL, head length; P_1, pectoral fin rays; SL, standard length.

Remarks. Although the present fossils are poorly preserved in head region, it clearly shows a character to be a member of the order Ichthyodectiformes by the uroneurals covering the lateral surfaces of the preural centra (Fig. 21). The Ichthyodectiformes contains 13 or 14 genera from Upper Jurassic to Lower Cretaceous deposits of all continents in the world (PATTERSON and ROSEN, 1977). Among them, the present new species is considered to belong to the genus *Chuhsiungichthys* from Upper Cretaceous of Yunnan Province (LEW, 1974) because this species is closest to *Chuhsiungichthys tsanglingensis* LEW, 1974 (Fig. 22) in the proportion and meristic characters with the exception of number of anal fin rays (D. 21–23; A. 39–40; V. 40–42 in *C. tsanglingensis*) (Tab. 2). This species differs from *Mesoclupea*, which has a single species *M. showchangensis* PING & YEN, 1933 (Fig. 23), from Late Jurassic of Zhejiang Province and Chekiang Province (PING and YEN, 1933; CHANG, 1963; CHANG and CHOU, 1974, 1977; CHANG and CHOW, 1986) in the position and the size of the dorsal fin (the dorsal fin is small and the dorsal base is situated above the middle of anal fin base in *Mesoclupea*) and the meristic characters (D. 14; A. 46; V. 53–54 in *Mesoclupea* and D. 20–21; A. 32; V. 40 in this species). *Chuhsiungichthys yanagidai* differs from *Chuhsiungichthys japonicus* with more slender body (the body depth is contained 2.4 to 2.5 times in the standard length in *C. japonicus*) and in the number of anal fin rays (Tab. 2).

Chuhsiungichthys japonicus sp. nov.

(Figs. 24–25, Pl. 41)

Diagnosis. This species differs from other species of the genus *Chuhsiungichthys* in having the combination of following characters. The dorsal fin is large. The dorsal

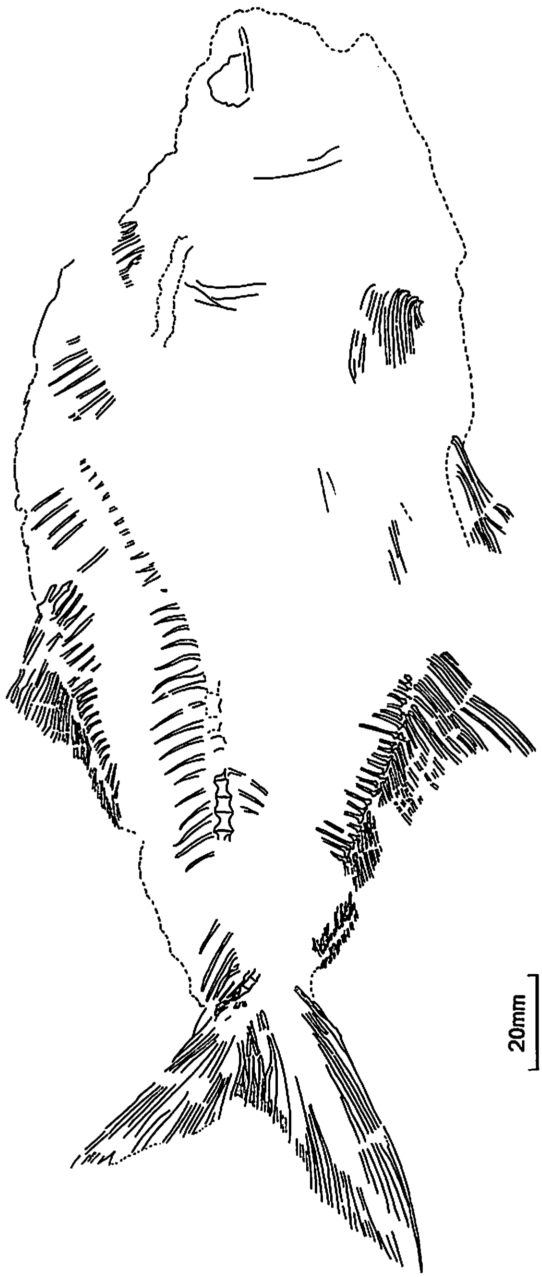

Fig. 24. *Chuhsiungichthys japonicus* sp. nov., the holotype, KMNH VP 100,150.

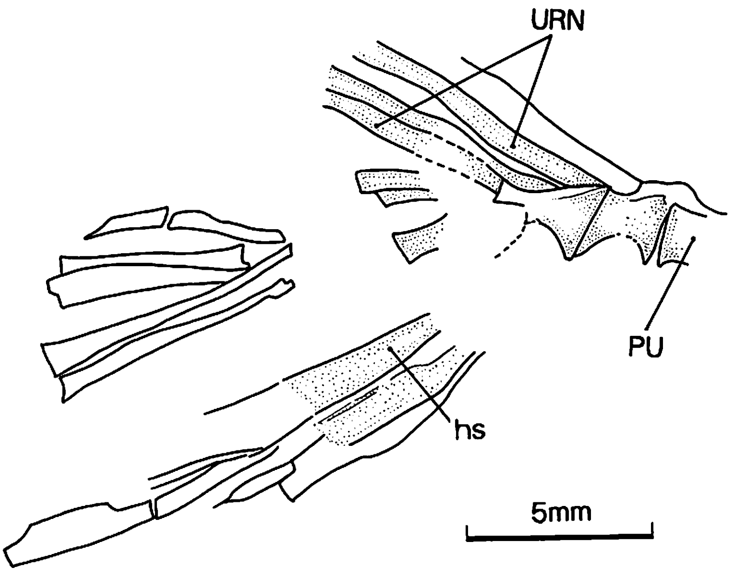

Fig. 25. *Chuhsiungichthys japonicus* sp. nov., caudal skeleton of the holotype, KMNH VP 100,150.

origin is slightly before the anal origin. The length of the dorsal fin base is contained 1.6 times in the anal fin base. The number of anal fin rays is 39. The body depth is contained 2.4 to 2.5 times in the standard length.

Holotype. KMNH VP 100,150, a specimen with its right side exposed, but the middle of the body and the dorsal part of the head region are missing. The standard length is 216.0 mm.

Paratype. KMNH VP 100,151, an almost complete specimen with its left side exposed, but a part of the head region and the posterior part of the caudal fin are missing. The standard length is 218.3 mm.

Locality. Kumagai (KD-34), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Fourth Formation (the uppermost formation, W_4, correlated to the Upper Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species name, *japonicus*, means Japan.

Description of the holotype.

The body is deep. The body depth is contained 2.4 times in the standard length. The head length is contained 4.2 times in the standard length. The outline from the occipital region to the dorsal origin is slightly convex. The restored outline of the abdomen is slightly convex and runs little under the lower end of each rib. The median fins are relatively posterior in position. The dorsal fin is large. The dorsal origin is slightly before the anal origin. The dorsal fin base is contained 1.6 times in the anal fin base. The pectoral fin is short and does not reach the pelvic insertion. The caudal fin is forked (Fig. 24). The number of principal dorsal fin rays is 21. There are 22 dorsal fin pterygiophores. The number of principal anal fin rays is 39. The principal dorsal fin rays are preceded by one small unbranched accessory ray. The principal anal fin rays are preceded by two small unbranched accessory rays. The number of pectoral fin rays is 18. There is a series of median supraneurals beginning close behind the head and ending before the dorsal origin. Each supraneural is cylindrical. There are two ural centra. Three uroneurals of the left side are visible. The anterior parts of the uroneurals cover the lateral faces of the ural centra and the first preural centrum (Fig. 25).

Description of the paratype.

The body depth is contained 2.5 times in the standard length. The number of principal anal fin rays is 39. There are 39 anal pterygiophores. The principal anal fin rays are preceded by three small unbranched accessory rays. There are 18 principal caudal fin rays (1,8,8,1).

Remarks. Although the present fossils are poorly preserved in the head region, it clearly shows a character to be a member of the order Ichthyodectiformes by the uroneurals covering the lateral surfaces of the preural centra (Fig. 25). The present species is considered to belong to the genus *Chuhsiungichthys,* because this species is closest to *Chuhsiungichthys tsanglingensis* (Fig. 22) in the meristic characters with the exception of the proportion (Tab. 2). This species is closer to *C. yanagidai,* but it differs from *C. yanagidai* with the body depth and the number of anal fin rays. The body depth is contained 2.4 to 2.5 times in the standard length in *C. japonicus*, 3.6 times in *C. yanagidai*. The number of anal fin rays is 39 in *C. japonicus*, 32 in *C. yanagidai*. (Tab. 2).

Chuhsiungichthys sp.

(Pl. 42)

Specimens. KMNH VP 100,152, a specimen with its right side exposed, the abdomen and the head region are poorly preserved. The dorso-anterior part of the

body and the posterior part of the caudal fin are missing. The anterior part of the body and the dorsal fin are moved. The standard length is 129.3 mm. KMNH VP 100,153, a specimen of the anterior part of the body. The anterior end of the head is missing, the bones of the abdominal part are moved and the bones of the head region are poorly preserved. KMNH VP 100,154, a specimen with its right side exposed. The caudal skeleton and fin, the anterior part of the head and the anterior part of the anal fin are missing. The bones of the abdominal part and the head region are moved.

Locality. Minamigaoka (KM-1), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Third Formation (the upper formation, W_3, correlated to the Lower Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Description.

In KMNH VP 100,152, the body depth is contained 3.9 times in the standard length. The median fins are relatively posterior in position. The dorsal origin is about vertical with the anal origin. The anal fin base is long. The dorsal fin base is about 1.8 times of the anal fin base. The number of principal dorsal fin rays is 21. There are 20 dorsal fin pterygiophores. Twelve principal anal fin rays are visible. Twenty-two anal fin pterygiophores are visible. Twenty-four caudal vertebrae are counted. There is a series of median supraneurals beginning close behind the head and ending before the dorsal origin. Each supraneural is cylindrical and long. The parhypural and the first and the second hypurals are almost same in size. The neural arch and spine of the first preural centrum are not complete. Four hypurals are visible. There is a space between the second and the third hypurals. The second ural centrum bears at least three hypurals (HYU3–5). Three uroneurals are visible. The number of epurals is 2. There are two ural centra. The anterior parts of the uroneurals cover the lateral faces of the first preural centrum.

In KMNH VP 100,153, the body is moderate. The outline of the head dorsal margin is convex. The outline from the occipital region to the dorsal origin is slightly convex. The restored outline of the abdomen is slightly convex. The anal origin is behind the dorsal origin and about vertical with the anterior half of the dorsal base. The pelvic fin is situated at almost middle of the abdomen and before the dorsal origin. The number of principal dorsal fin rays is 21. There are 22 dorsal fin pterygiophores. The principal dorsal fin rays are preceded by two small unbranched accessory rays. The principal anal fin rays are preceded by three small unbranched accessory rays. There is a series of median supraneurals beginning close behind the head and ending before the dorsal origin. Each supraneural is

slender and long.

In KMNH VP 100,154, the body depth is moderate. The median fins are relatively posterior in position. The anal fin base is long. The pectoral fin reaches the pelvic insertion. The number of principal dorsal fin rays is over 11. The number of dorsal fin pterygiophores is over 10. The number of anal fin pterygiophores is over 28. The principal dorsal fin rays are preceded by two small unbranched accessory rays. The number of pectoral fin rays is 18. The number of pelvic fin rays is 7. The total number of vertebrae is over 46 or 47, with over 26 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae was estimated on the basis of the ribs. Eighteen or nineteen ribs can be counted. There is a series of median supraneurals beginning close behind the head and ending before the dorsal pterygiophore. Each supraneural is slender and long.

Remarks. Although the present fossils are poorly preserved, three fossils are considered to belong to a same species in having the following characters: 1) the long anal fin base, 2) almost same number of dorsal fin rays, and 3) same forms of the body, median supraneurals, dorsal fin, anal fin and vertebral column. It clearly shows a character to be a member of the order Ichthyodectiformes by the uroneurals covering the lateral faces of the preural centra. This species is considered to be closest to *Chuhsiungichthys yanagidai* in having the large dorsal fin, the same number of dorsal fin rays and the relative position of the median fins, but it differs from *C. yanagidai* in having larger number of vertebrae. The number of vertebrae is 46 or 47, in this species, 40 in *C. yanagidai*. The present author does not describe this species as a new species until better specimens are collected.

Infradivision Osteoglossomorpha
Order Osteoglossiformes
Family Lycopteridae
Genus ***Yungkangichthys*** CHANG & CHOU, 1974

Diagnosis. It differs from other genera of the family Lycopteridae in having the combination of following characters. The body is remarkably deep. The body depth is contained 1.7 to 2.1 times in the standard length. The number of branched caudal fin rays is 15. The outline of the abdomen rapidly ascends in front of the anal origin. The number of vertebrae is 44, with 22 caudal vertebrae. The number of ribs is 18. The number of dorsal fin rays is 11. The number of anal fin rays is 19.

Type species. *Yungkangichthys hsitanensis* CHANG & CHOU, 1974.

Yungkangichthys macrodon sp. nov.

(Figs. 26–28, Pl. 43.)

Diagnosis. It differs from other species of the genus *Yungkangichthys* in having the combination of following characters. The body is deep and the body depth is contained 1.7 times in the standard length. The length of the centrum is longer than the depth. Large canine like teeth are present on the parasphenoid. The number of abdominal vertebrae is 20. The number of ribs is 18. The estimated maximum size is over 200 mm in standard length.

Holotype. KMNH VP 100,183, a specimen of the anterior part of the body, with its lateral side exposed. The caudal and dorsal parts of the body, the anterior end and the ventral part of the head region are missing. The length of the preserved portion is 73.3 mm along the body axis. The estimated standard length is 205.3 mm.

Locality. Kumagai (KA-0), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

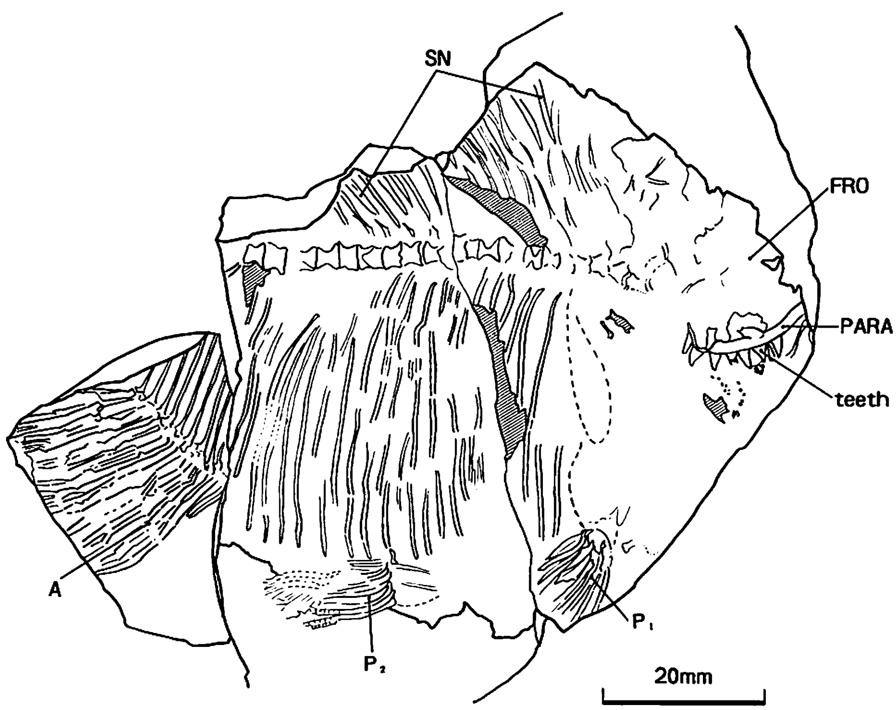

Fig. 26. *Yungkangichthys macrodon* sp. nov., the holotype, KMNH VP 100,183.

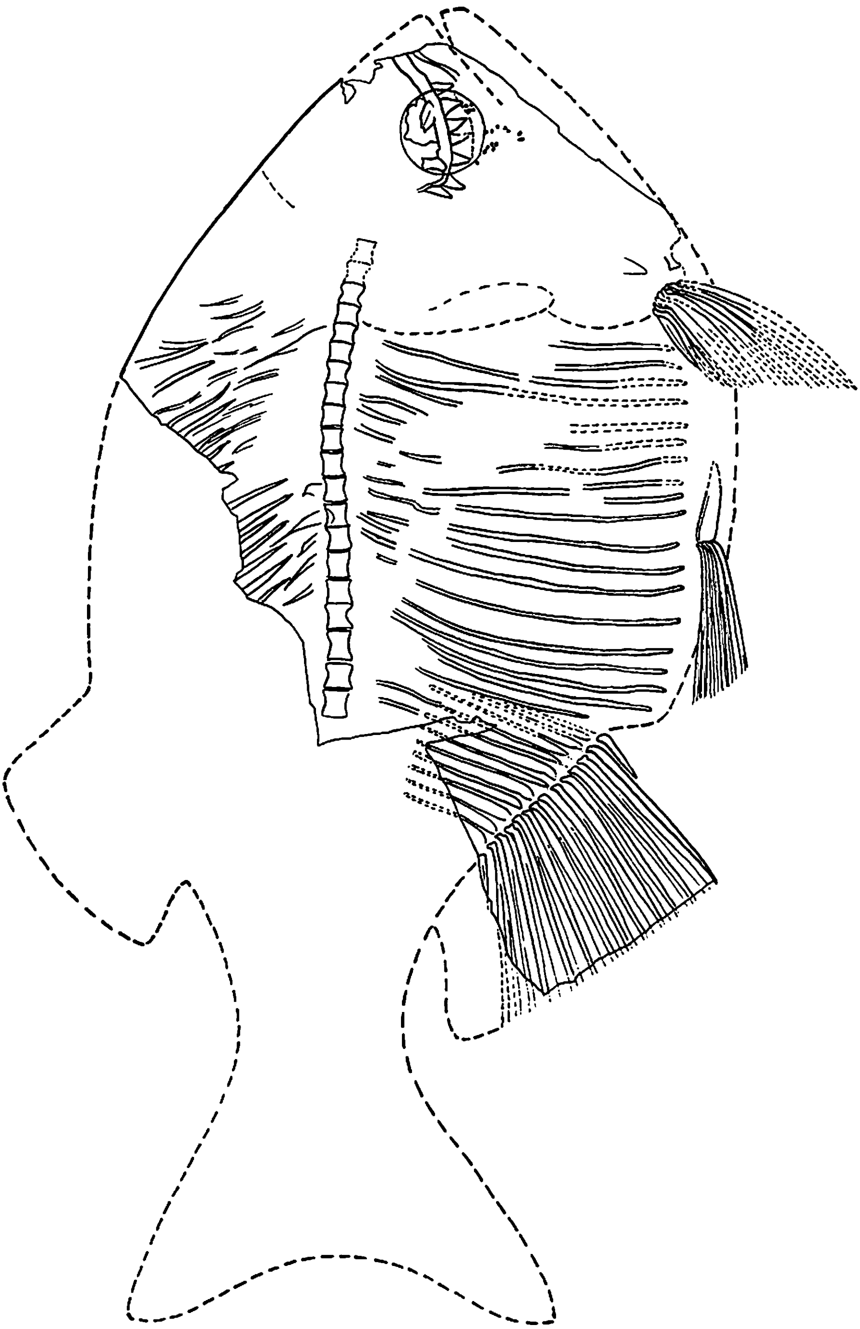

Fig. 27. *Yungkangichthys macrodon* sp. nov., restoration of the skeleton.

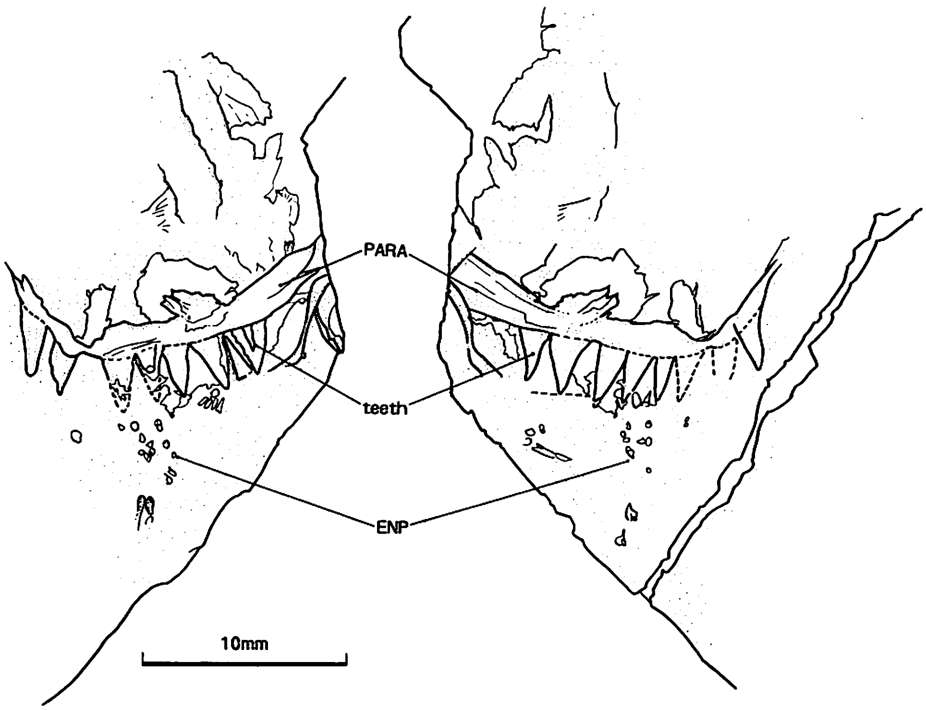

Fig. 28. *Yungkangichthys macrodon* sp. nov., head region of the holotype, KMNH VP 100,183.

Horizon. The Fourth Formation (the uppermost formation, W_4, correlated to the Upper Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species name, *macrodon,* means large teeth, which refers to the fact that this species has the large teeth on the parasphenoid.

Description of the holotype.

The body is deep. The body depth is contained 1.7 times in the standard length in estimation. The head length is contained 3.8 times in the standard length in estimation. The outline of the head dorsal margin is slightly convex. The restored outline from the occipital region to the dorsal origin is slightly convex. The restored outline of the abdomen is slightly convex and rapidly ascends in front of the anal origin (Figs. 26 and 27). The dorsal fin is missing. The anal fin is large and each fin ray is long and is not slender. The anal fin pterygiophores are slender and long. The pectoral fin is situated near the ventral edge of the body at the postero-ventral corner of the head. The pelvic fin is situated at the middle of ventral edge of abdomen. The number of principal anal fin rays is over 11. The number of anal fin pterygiophores is over 10. The principal anal fin rays are preceded by two

small unbranched accessory rays. Ten pectoral fin rays are visible. Six pelvic fin rays are visible. Large canine like teeth are present on the parasphenoid. There are villiform teeth on the endopterygoid (Fig. 28). The total number of abdominal vertebrae is 20. The number of ribs is 18. There is a series of median supraneurals beginning immediately behind the head. Each supraneural is cylindrical.

Remarks. The present fossil clearly shows a character to be a member of the order Osteoglossiformes by the presence of large teeth on the parasphenoid. Seven families and about twenty genera of the Osteoglossomorpha are known from the Upper Jurassic to Recent in Africa, America, East Indies, Australia and Asia. Among them, most Mesozoic genera (excepting *Chandlerichthys* from Middle Cretaceous deposits of North America by GRANDE, 1986) are known from the Upper Jurassic to Lower Cretaceous time of eastern Asia. These are *Lycoptera, Asiatolepis, Paralycoptera, Yungkangichthys, Yanbiania, Tongxinichthys* and *Plesiolycoptera* (TAKAI, 1943; LIU H.-T. *et al.*, 1963; LI, 1987; CHANG and CHOU, 1974, 1976, 1977, 1986; MA, 1980).

Among these Mesozoic genera, the present fossil is considered to belong to the genus *Yungkangichthys* from the Upper Cretaceous of Zhejiang province in China (CHANG and CHOU, 1974), because it is closest to *Yungkangichthys hsitanensis* CHANG & CHOU, 1974 (Fig. 29) in having the deep body, large canine like teeth and a rapid ascent of the outline of the abdomen in front of the anal origin, but this new species, *Yungkangichthys macrodon,* differs from *Y. hsitanensis* in following characters. The parasphenoid teeth are larger than those of *Y. hsitanensis.* The length of the centrum is longer than the depth in *Y. macrodon.* The length of the centrum is shorter than the depth in *Y. hsitanensis.* The body depth is contained 1.7 time in the standard length in *Y. macrodon,* 2.1 times in *Y. hsitanensis.* The estimated maximum size is over 200 mm in standard length in *Y. macrodon.* The standard length is 36 mm in *Y. hsitanensis.*

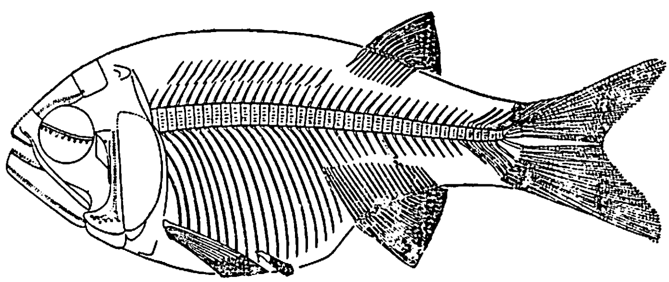

Fig. 29. *Yungkangichthys hsitanensis* CHANG & CHOU, 1974. From CHANG and CHOU, 1977.

Genus *Aokiichthys* gen. nov.

Diagnosis. It differs from other genera of the family Lycopteridae in having the combination of following characters. The dorsal origin is vertical with the anal origin, before or behind the anal origin. The dorsal fin is small. The number of vertebrae is 34 to 36, with 17 to 19 caudal vertebrae. The number of ribs is 14 to 15. The number of branched caudal fin rays is 15. The length of the anal fin base is long and is contained 1.6 to 2.3 times in the length of the dorsal fin base. The large teeth are present on the parasphenoid. The pectoral fin is long and reaches or extends over the pelvic insertion. The number of dorsal fin rays is 9 to 12. The number of anal fin rays is 17 to 21. The range of size is 34.8 to 146.7 mm in standard length.

Type species. *Aokiichthys toriyamai* sp. nov.

Etymology. The generic name, *Aokiichthys* consists of *Aoki*, the name of Mr. Tateyu Aoki, who collected and donated most specimens of this genus to the Kitakyushu Museum and Institute of Natural History, and *ichthys*, a Greek word meaning fish.

Remarks. The combination of following characters indicates that this new genus, *Aokiichthys*, is a member of the teleostean fish order Osteoglossiformes: 1) the median fins are relatively posterior in position, 2) the large teeth are present on the parasphenoid, 3) the premaxilla and dentary have canine like teeth, 4) the pectoral fin is long, 5) the series of supraneurals are present.

Seven families and about twenty genera of the Osteoglossomorpha are known from the Upper Jurassic to Recent in Africa, America, East Indies, Australia and Asia.

Among them, most Mesozoic genera (excepting *Chandlerichthys* from Middle Cretaceous deposits of North America by GRANDE, 1986) are known from Upper

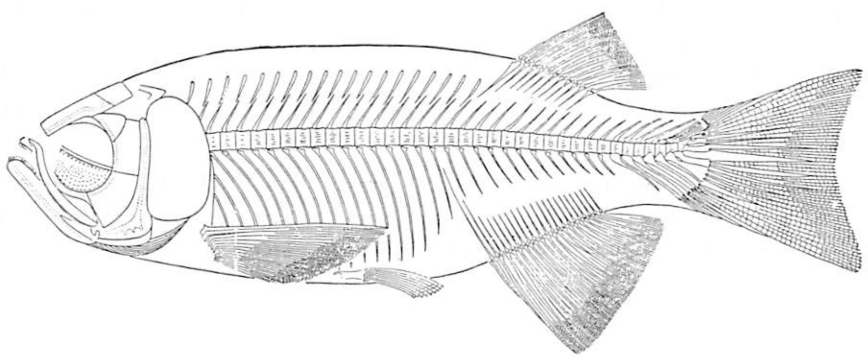

Fig. 30. *Paralycoptera wui* CHANG & CHOU, 1974. From CHANG and CHOU, 1977.

Table 3. Comparison of the characters of the lycopterid species having 15 branched

	Aokiichthys toriyamai gen. et sp. nov.	*A. changae* gen. et sp. nov.	*A. otai* gen. et sp. nov.	*A. uyenoi* gen. et sp. nov.
SL	34.8–74.9 mm	62.5–83.1 mm	55.3–60.2 mm	46.3–69.4 mm
counts				
D.	9–12	9–11	11–12	9–11
A.	18–20	17–19	19	18–21
V.	35–36 (16–17+17–19)	35–36 (16–17+18–19)	34–36 (16–17+17–19)	34–35 (16–17+17–18)
ribs	14–15	14–15	14–15	14–15
ratio				
SL/BD	3.0–3.7	3.2–3.7	2.1–2.4	2.1–2.5
AB/DB	1.6–2.1	1.6–2.2	1.8–1.9	1.7–2.3
D/=A*	D=A	A/D	D=A	A/D

A., anal fin rays; AB, anal fin base; BD, body depth; D., dorsal fin rays; DB, dorsal fin base; SL, standard length; V., vertebrae.

* The position of the dorsal and anal origins. D/A, the dorsal origin is before the anal origin. D=A, the dorsal origin is vertical with the anal origin. A/D, the dorsal origin is behind the anal origin.

Jurassic to Lower Cretaceous time in eastern Asia. These are *Lycoptera, Asiatolepis, Paralycoptera, Yungkangichthys, Yanbiania, Tongxinichthys* and *Plesiolycoptera* (TAKAI, 1943; LIU H.-T. *et al.*, 1963; CHANG and CHOU, 1974, 1976, 1977, 1986; MA, 1980; LI, 1987). Among these Mesozoic genera, *Aokiichthys* is close to the genus *Paralycoptera,* which has two species *P. wui* CHANG & CHOU, 1974 (Fig. 30) and *P. changi* MA & SUN, 1988, and the genus *Yungkangichthys,* which has only species *Y. hsitanensis* CHANG & CHOU, 1974 (Fig. 29), from Early Cretaceous deposits of Zhejiang and Jilin (CHANG and CHOU, 1974, 1977; MA and SUN, 1988) in having 15 branched caudal fin rays and the large teeth on the parasphenoid. These two genera belong to the family Lycopteridae (CHANG and CHOU, 1974, 1977). But *Aokiichthys* differs from *Paralycoptera* and *Yungkangichthys* with the smaller number of vertebrae and ribs. The number of vertebrae is 34 to 36 with 17 to 19 caudal vertebrae in *Aokiichthys,* 40 to 42 with 20 caudal vertebrae in *Paralycoptera,* 44 with 22 caudal vertebrae in *Yungkangichthys.* The number of ribs is 14 to 15 in *Aokiichthys,* 20 to 22 in *Paralycoptera,* 16 in *Yungkangichthys.* (Tab. 3).

The number of vertebrae (34 to 36) is the fewest in the Osteoglossomorpha. GREENWOOD (1970) listed lycopterid species with as few as forty. *Kipalaichthys sekirskyi* has 38 to 40 vertebrae (CASIER, 1965; TAVERNE, 1979).

caudal fin rays from Kitakyushu and China.

A. praedorsalis gen. et sp. nov.	*Paralycoptera wui*	*Yungkangichtys hsitanesis*
57.7–146.7 mm	67.0 mm	36.0 mm
11–13	10	11
15–17	18	19
35 (17+18)	40–42 (20–22+20)	44 (22+22)
15	20–22	16(20?)
2.7–2.8	3.0–3.4	2.1
1.2		
D/A	A/D	D=A

Aokiichthys toriyamai **sp. nov.**

(Figs. 31–34, Pl. 44)

Diagnosis. It differs from other species of the genus *Aokiichthys* in having the combination of following characters. The body is moderate and the body depth is contained 3.0 to 3.7 times in the standard length. The median fins are relatively posterior in position. The dorsal origin is vertical with the anal origin. The number of principal dorsal fin rays is 9 to 12. The number of principal anal fin rays is 18 to 20. The range of size is 34.8 to 74.9 mm in standard length. The number of vertebrae is 35 to 36, with 17 to 19 caudal vertebrae. The number of ribs is 14 to 15.

Holotype. KMNH VP 100,160, an almost complete specimen, with its left side exposed. The standard length is 34.8 mm.

Paratypes. KMNH VP 100,160, an almost complete specimen with its left side exposed, with the counter part of the anterior part of the body. The standard length is 40.2 mm. KMNH VP 100,162, an almost complete specimen with its right side exposed. The standard length is 72.8 mm. KMNH VP 100,163, an almost complete specimen with its left side exposed, but a part of dorsal fin and a posterior part of the lower lob of the caudal fin are missing. The standard length is 36.7 mm. KMNH VP 100,164, an almost complete specimen with its left side exposed. The standard length is 74.9 mm. KMNH VP 100,165, an almost complete specimen with its left side exposed. The standard length is 71.1 mm.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyu-

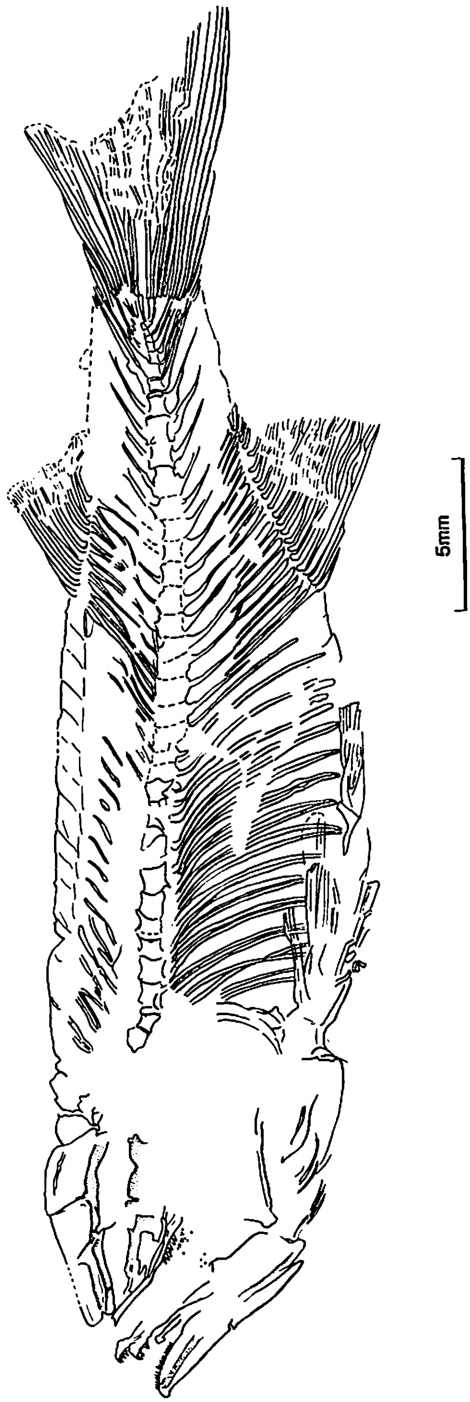

Fig. 31. *Aokiichthys toriyamai* gen. et sp. nov., the holotype, KMNH VP 100,160.

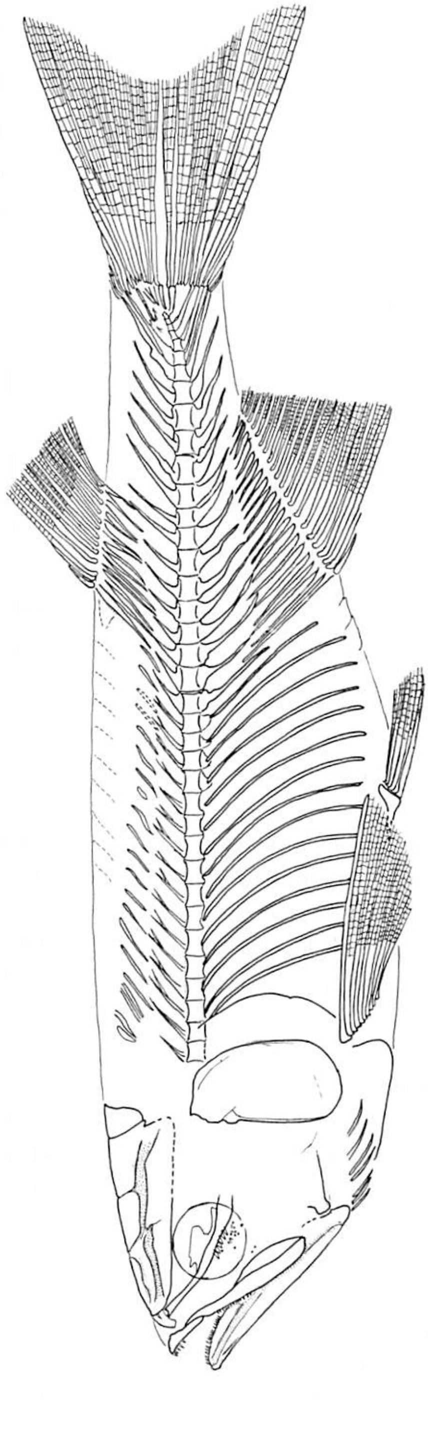

Fig. 32. *Aokiichthys toriyamai* gen. et sp. nov., restoration of the skeleton.

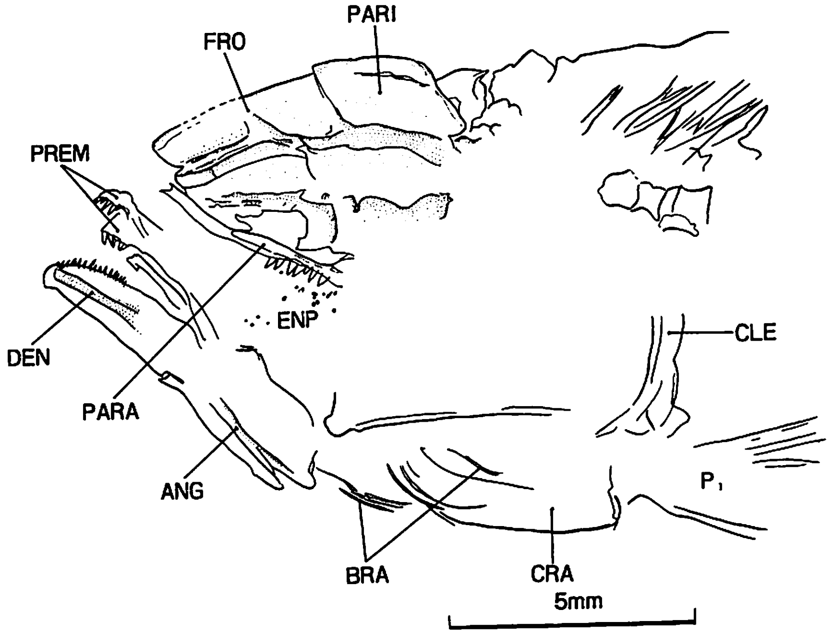

Fig. 33. *Aokiichthys toriyamai* gen. et sp. nov., head region of the holotype, KMNH VP 100,160.

shu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species is named for the late Dr. Ryuzo TORIYAMA who was the advisor to the first and second excavations of the Cretaceous fish fossils in Kitakyushu City.

Description of the holotype.

The body is moderate. The body depth is contained 3.4 times in the standard length. The head length is contained 3.3 times in the standard length. The snout is pointed. The outline of the head dorsal margin is slightly convex. The outline from the occipital region to the dorsal origin is almost straight (Fig. 31). The restored outline of the abdomen is slightly convex and runs little under the lower end of each rib (Fig. 32).

The median fins are relatively posterior in position. The dorsal origin is about vertical with the anal origin. The first dorsal fin pterygiophore is above the second caudal vertebra. The dorsal fin base is about half of the anal fin base. The

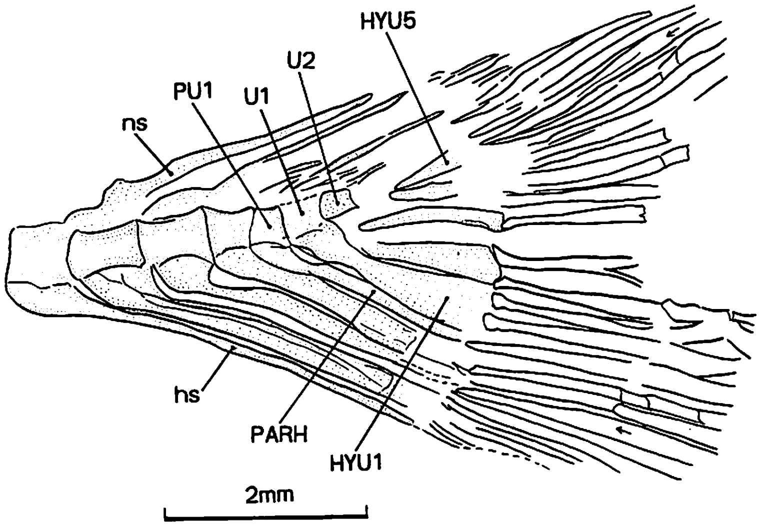

Fig. 34. *Aokiichthys toriyamai* gen. et sp. nov., caudal region of the holotype, KMNH VP 100,160.

pectoral fin elongates and reaches the pelvic insertion. The caudal fin is emarginate. The number of principal dorsal fin rays is 12. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 20. There are 20 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively. Ten pectoral fin rays are visible. There are 17 principal caudal fin rays (1,7,8,1).

The gape of the mouth is large. The lower jaw is long and narrow. The dentary bears small canine like teeth on its oral margin. The suture between the dentary and the anglo-articular is not visible. The premaxilla also bears small canine like teeth. The premaxillary teeth are larger than the dentary teeth. The posterior end of the lower jaw is placed below the posterior margin of the orbit. Seven large canine like teeth are preserved almost at center of the orbit on the parasphenoid. These teeth are larger than those of the premaxilla and the dentary. There are villiform teeth on the endopterygoid. Seven branchiostegal rays are visible. The frontal is long and carries a superficial long canal. The canal has a lateral branch at the middle of the frontal. The canal is not separated at the posterior end (Fig. 33).

The total number of vertebrae is 35, with 18 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae is estimated on the basis of the ribs. The number of ribs is 15. There is a series of median supraneurals beginning behind the head and ending above the second caudal vertebra. Each supraneural is cylindrical. The scale are visible at the dorsal part.

The estimated number of scales is 17 or 18 from the posterior end of the head to the dorsal origin.

The first preural centrum bears the cylindrical parhypural. Five hypurals are visible. The first hypural is the largest. The second hypural is about three-fifths of the first one in width. There is a space between the second and the third hypurals. The third to fifth hypurals are slender. There are two ural centra. The epural is not visible (Fig. 34).

Description of the paratypes.

In KMNH VP 100,161, the body depth is contained 3.1 times in the standard length. The head length is contained 3.1 times in the standard length. The dorsal fin base is contained 1.6 times in the anal fin base. The number of principal anal fin rays is 18. There are 18 anal fin pterygiophores. The number of ribs is 14.

In KMNH VP 100,162, the body depth is contained 3.3 times in the standard length. The head length is contained 3.5 times in the standard length. The first dorsal fin pterygiophore is above the first caudal vertebra. The dorsal fin base is contained 2.1 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 18. There are 18 anal fin pterygiophores. The total number of vertebrae is 34, with 17 caudal vertebrae.

In KMNH VP 100,163, the body depth is contained 3.1 times in the standard length. The head length is contained 3.0 times in the standard length. The first dorsal fin pterygiophore is above the second caudal vertebra. There are 9 dorsal fin pterygiophores. The number of principal anal fin rays is 18. There are 18 anal fin pterygiophores. There are villiform teeth on the endopterygoid. Five large canine like teeth are visible on the parasphenoid at the posterior part of orbit.

In KMNH VP 100,164, the body depth is contained 3.7 times in the standard length. The head length is contained 3.5 times in the standard length. The first dorsal fin pterygiophore is above the second caudal vertebra. The dorsal fin base is contained 1.6 times in the anal fin base. The number of principal dorsal fin rays is 11. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores.

In KMNH VP 100,165, the body depth is contained 3.0 times in the standard length. The head length is contained 3.9 times in the standard length. The dorsal fin base is contained 1.7 times in the anal fin base. The number of principal dorsal fin rays is 9. There are 9 dorsal fin pterygiophores. The number of principal anal fin rays is 19. Six pelvic fin rays are present. The total number of vertebrae is 36, with 19 caudal vertebrae. The number of ribs is 15.

Remarks. This new species, *Aokiichthys toriyamai*, resemble *Paralycoptera wui* CHANG & CHOU, 1974 (Fig. 30) in having almost same number of dorsal and anal fin rays,

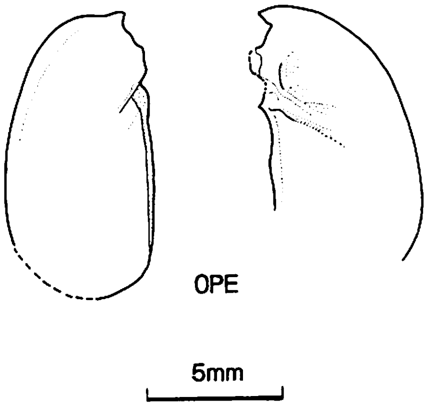

Fig. 35. The opercle of *Aokiichthys* sp., KMNH VP 100,172.

the almost same proportion and the size (Tab. 3). But it differs from *P. wui* in having the smaller number of vertebrae and ribs. The number of vertebrae is 35 to 36 with 17 to 19 caudal vertebrae in *A. toriyamai*, 40 to 42 with 20 caudal vertebrae in *P. wui*. The number of ribs is 14 to 15 in *A. toriyamai*, 20 to 22 in *P. wui* (Tab. 3). *A. toriyamai* is closest to *Aokiichthys changae* (Figs. 36–39) in having almost same meristic characters and almost same proportion in the genus *Aokiichthys*, with the exception of the relative position of median fins. The origin of the dorsal fin is vertical with the anal origin in *A. toriyamai*. The origin of the dorsal fin is behind of the anal origin in *A. changae*.

Aokiichthys changae sp. nov.

(Figs. 36–39, Pl. 45)

Diagnosis. It differs from other species of the genus *Aokiichthys* in having the combination of following characters. Large teeth are present on the parasphenoid. The body is moderate and the body depth is contained 3.2 to 3.7 times in the standard length. The median fins are relatively posterior in position. The dorsal origin is behind the anal origin and vertical with the fifth anal fin pterygiophore (about anterior one third of the anal fin base). The number of principal dorsal fin rays is 9 to 11. The number of principal anal fin rays is 17 to 19. The range of size is 62.5 to 83.1 mm in standard length. The number of vertebrae is 35 to 36, with 18 to 19 caudal vertebrae. The number of ribs is 14 to 15.

Holotype. KMNH VP 100,166, an almost complete specimen with its right side exposed. The standard length is 67.3 mm.

Paratypes. KMNH VP 100,167, an almost complete specimen with its left side

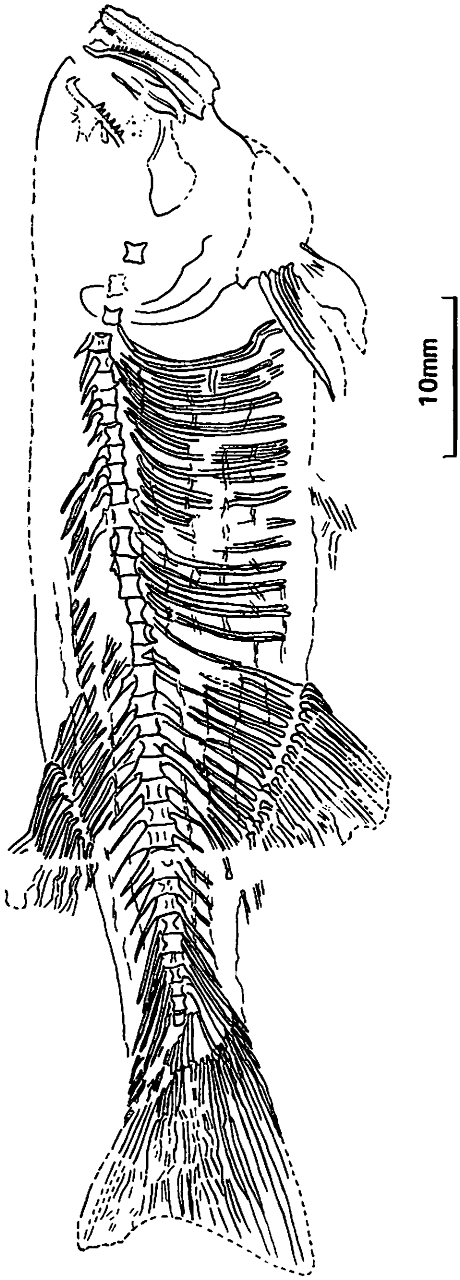

Fig. 36. *Aokiichthys changae* gen. et sp. nov., the holotype, KMNH VP 100,166.

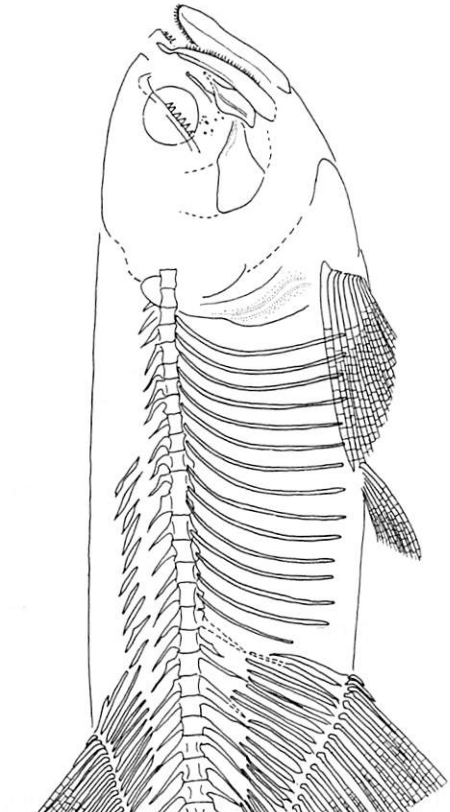

Fig. 37. *Aokiichthys changae* gen. et sp. nov., restoration of the skeleton.

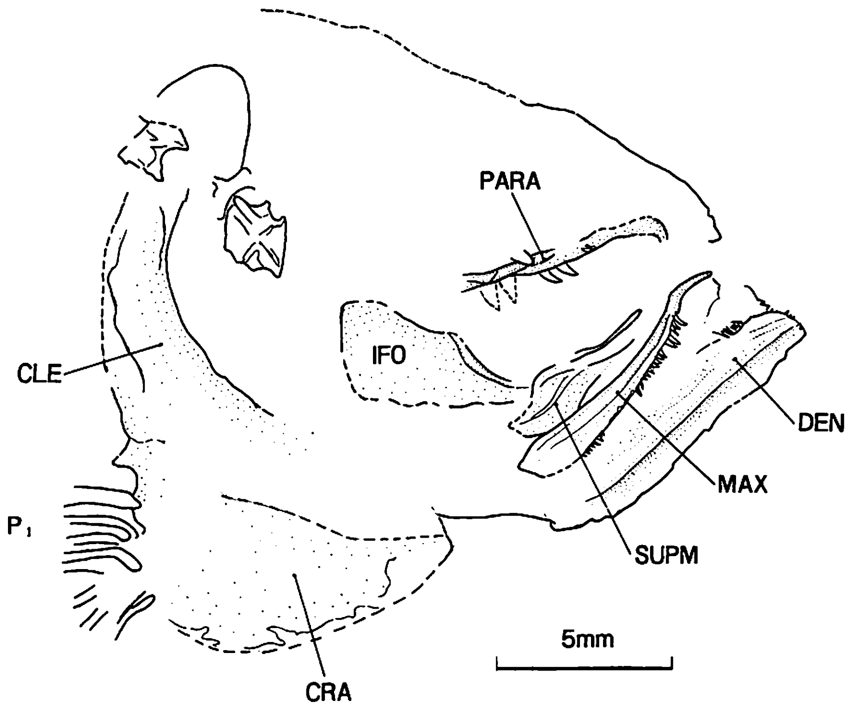

Fig. 38. *Aokiichthys changae* gen. et sp. nov., head region of the holotype, KMNH VP 100,166.

exposed. The standard length is 69.7 mm. KMNH VP 100,168, an almost complete specimen with its left side exposed, but the pelvic fin is missing. The standard length is 76.1 mm. KMNH VP 100,169, an almost complete specimen with its left side exposed. The standard length is 83.1 mm. KMNH VP 100,170, an almost complete specimen with its left side exposed, but the posterior end of the caudal fin is missing. The standard length is 62.5 mm. KMNH VP 100,171, an almost complete specimen with its right side exposed, but the posterior part of the caudal fin is missing. The standard length is 70.5 mm.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species is named for Dr. CHANG Mee-mann, a paleontologist of China who has contributed to the study of the Mesozoic fish fossils in China.

Description of the holotype.

The body is moderate. The body depth is contained 3.5 times in the standard length. The head length is contained 3.8 times in the standard length. The snout is rounded. The outline of the head dorsal margin is slightly convex. The outline from the occipital region to the dorsal origin is almost straight (Fig. 36). The restored outline of the abdomen is almost straight and runs little under the lower end of each rib (Fig. 37). The median fins are relatively posterior in position.

The dorsal origin is behind the anal origin and vertical with the fifth anal fin pterygiophore (about anterior one third of the anal base). The first dorsal fin pterygiophore is above the first and second caudal vertebrae. The dorsal fin base is contained 2.1 times in the anal fin base. The pectoral fin is moderate and reaches the pelvic insertion. The caudal fin is emarginate. The number of principal dorsal fin rays is 11. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively. Seven pectoral fin rays are visible. There are 17 principal caudal fin rays (1,7,8,1).

The gape of the mouth is large. The lower jaw is long and narrow. The dentary bears small canine like teeth on its oral margin. The suture between the dentary and angulo-articular is not visible and the posterior part of the lower jaw is poor in preservation. The maxilla bears teeth almost entirely on its oral margin. The maxillary teeth are larger than the dentary teeth. The posterior end of the

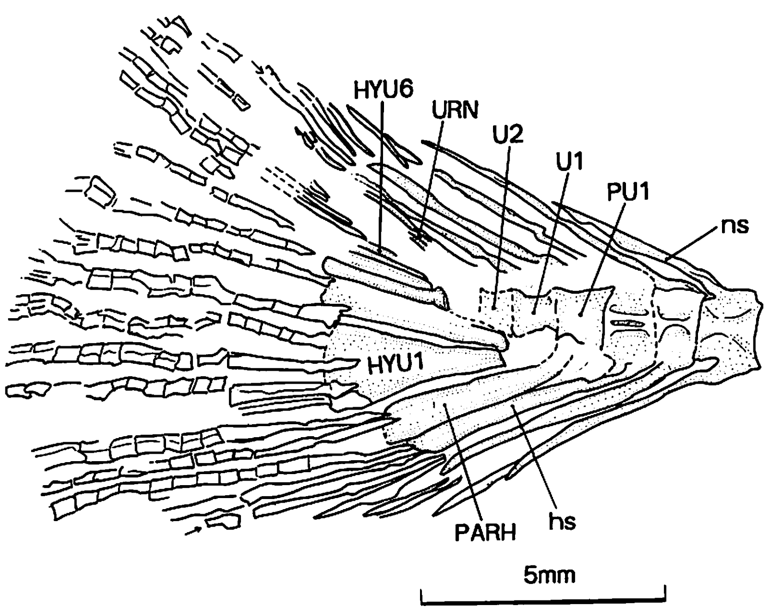

Fig. 39. *Aokiichthys changae* gen. et sp. nov., caudal region of the holotype, KMNH VP 100,166.

lower jaw is placed below almost center of the orbit. Four large canine like teeth are preserved on the parasphenoid at almost center of the orbit. These teeth are larger than those of the premaxilla, maxilla and dentary. One infraorbital is visible and have a sensory canal along the orbital margin. The supramaxilla is present and is leaf-shape (Fig. 38).

The total number of vertebrae is 36, with 19 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae is estimated on the basis of ribs. The number of ribs is 15. There is a series of median supraneurals ending above the first caudal vertebra. Each supraneural is cylindrical.

The first preural centrum bears the narrow parhypural. The neural arch and spine of the first preural centrum are complete. Six hypurals are visible. The first hypural is the largest. The third to sixth hypurals are slender. There are two ural centra. The second ural centrum bears at least three hypurals (HYU3–5). Three uroneurals are visible. The anterior ends of the uroneurals are not visible. The epural is not visible (Fig. 39).

Description of the paratypes.

In KMNH VP 100,167, the body depth is contained 3.7 times in the standard length. The head length is contained 3.8 times in the standard length. The dorsal fin base is contained 1.6 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 17. There are 18 anal fin pterygiophores. There are 9 pectoral fin rays. The total number of vertebrae is 36, with 19 caudal vertebrae.

In KMNH VP 100,168, the body depth is contained 3.5 times in the standard length. The head length is contained 4.0 times in the standard length. The dorsal fin base is contained 1.9 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 19. The total number of vertebrae is 36, with 19 caudal vertebrae.

In KMNH VP 100,169, the body depth is contained 3.3 times in the standard length. The head length is contained 3.7 times in the standard length. The first dorsal fin pterygiophore is above the second caudal vertebra. The dorsal fin base is contained 2.2 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores.

In KMNH VP 100,170, the body depth is contained 3.3 times in the standard length. The head length is contained 4.1 times in the standard length. The first dorsal fin pterygiophore is above the second caudal vertebra. The dorsal fin base is contained 1.7 times in the anal fin base. The number of principal dorsal fin rays is 9. The number of principal anal fin rays is 19. Nine pectoral fin rays are visible. The total number of vertebrae is 35, with 18 caudal vertebrae. The number of ribs is 15.

In KMNH VP 100,171, the body depth is contained 3.2 times in the standard length. The head length is contained 4.2 times in the standard length. The first dorsal fin pterygiophore is above the second caudal vertebra. The dorsal fin base is contained 2.0 times in the anal fin base. The number of principal dorsal fin rays is 10. There are 10 dorsal fin pterygiophores. The number of principal anal fin rays is 21. There are 21 anal fin pterygiophores. The total number of vertebrae is 36, with 19 caudal vertebrae.

Remarks. This new species, *Aokiichthys changae,* resemble *Paralycoptera wui* CHANG & CHOU, 1974 (Fig. 30) in having almost same number of dorsal and anal fin rays and almost same in the proportion and the size (Tab. 3). However, it differs from *P. wui* in having fewer vertebrae and ribs. The number of vertebrae is 35 to 36 with 18 to 19 caudal vertebrae in *A. changae,* 40 to 42 with 20 caudal vertebrae in *P. wui.* The number of ribs is 14 to 15 in *A. changae,* 20 to 22 in *P. wui* (Tab. 3). *A. changae* is closest to *Aokiichthys toriyamai* (Figs. 27–30) in having almost same meristic characters and almost same proportion and size in the genus *Aokiichthys* with the exception of the relative position of median fins (Tab. 3). The origin of the dorsal fin is vertical with the fifth anal fin pterygiophore in *A. changae.* The origin of the dorsal fin is vertical with the anal origin in *A. toriyamai.*

Aokiichthys otai sp. nov.

(Figs. 40–43, Pl. 46)

Diagnosis. It differs from other species of the genus *Aokiichthys* in having the combination of following characters. Large teeth are present on the parasphenoid. The body is deep and the body depth is contained 2.1 to 2.4 times in the standard length. The median fins are relatively posterior in position. The dorsal origin is vertical with the anal origin. The number of principal dorsal fin rays is 11 to 12. The number of principal anal fin rays is 19. The range of size is 55.3 to 60.2 mm in standard length. The number of vertebrae is 34 to 36, with 17 to 19 caudal vertebrae. The number of ribs is 14 to 15.

Holotype. KMNH VP 100,173, an almost complete specimen, with its left side exposed. The standard length is 55.3 mm.

Paratypes. KMNH VP 100,174, an almost complete specimen with its right side exposed, but the upper lob of the caudal fin is missing. The standard length is 60.2 mm. KMNH VP 100,175, an almost complete specimen with its left side exposed. The standard length is 60.2 mm.

Etymology. The species is named for Dr. Masamichi OTA who organized the first

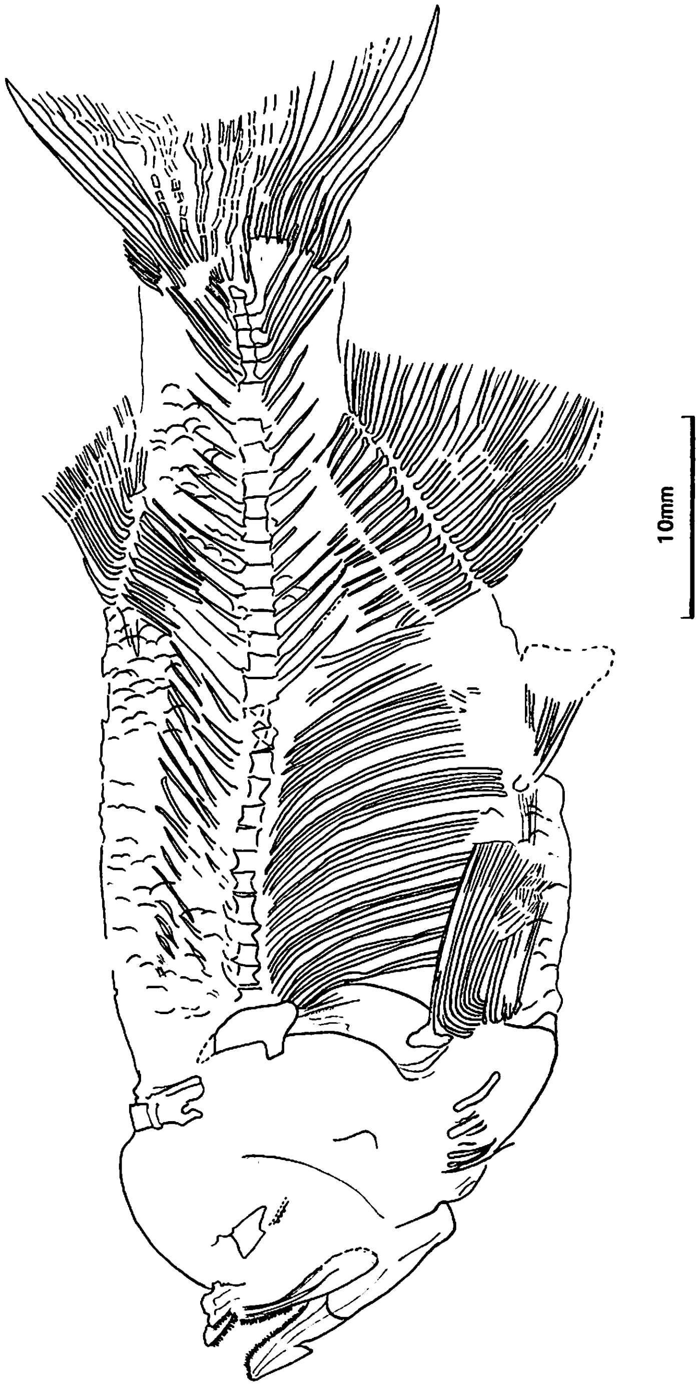

Fig. 40. *Aokiichthys otai* gen. et sp. nov., the holotype, KMNH VP 100,173.

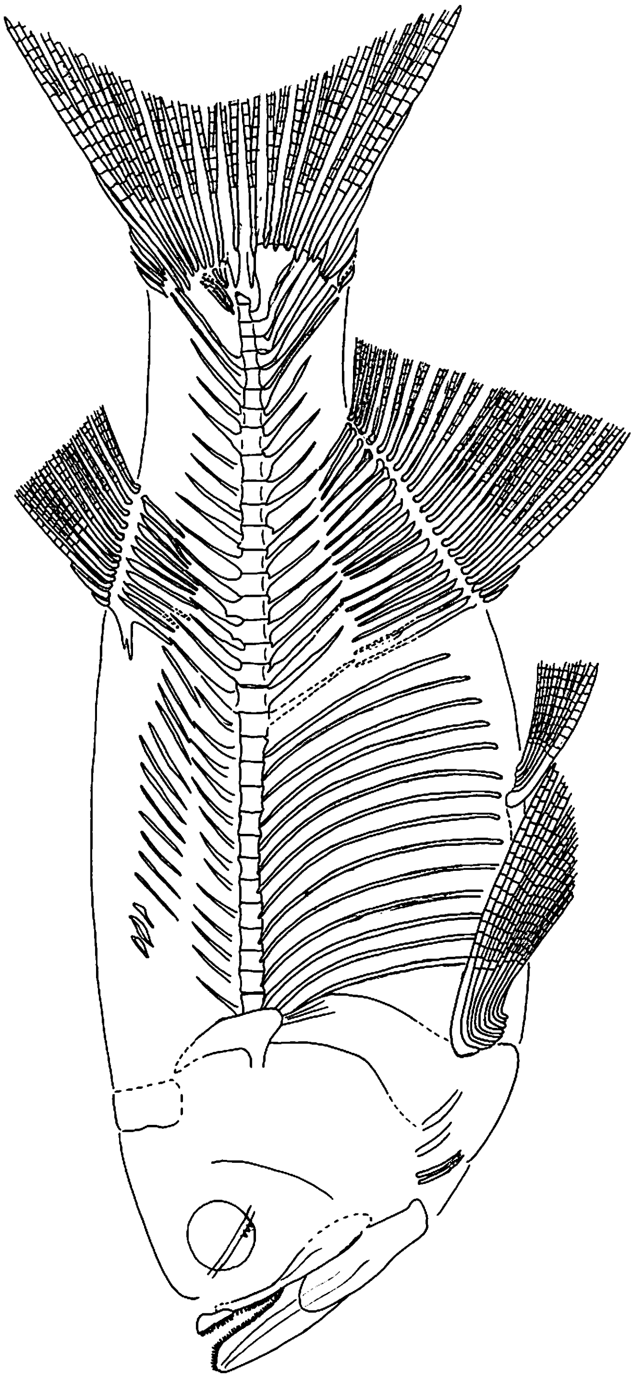

Fig. 41. *Aokiichthys otai* gen. et sp. nov., restoration of the skeleton.

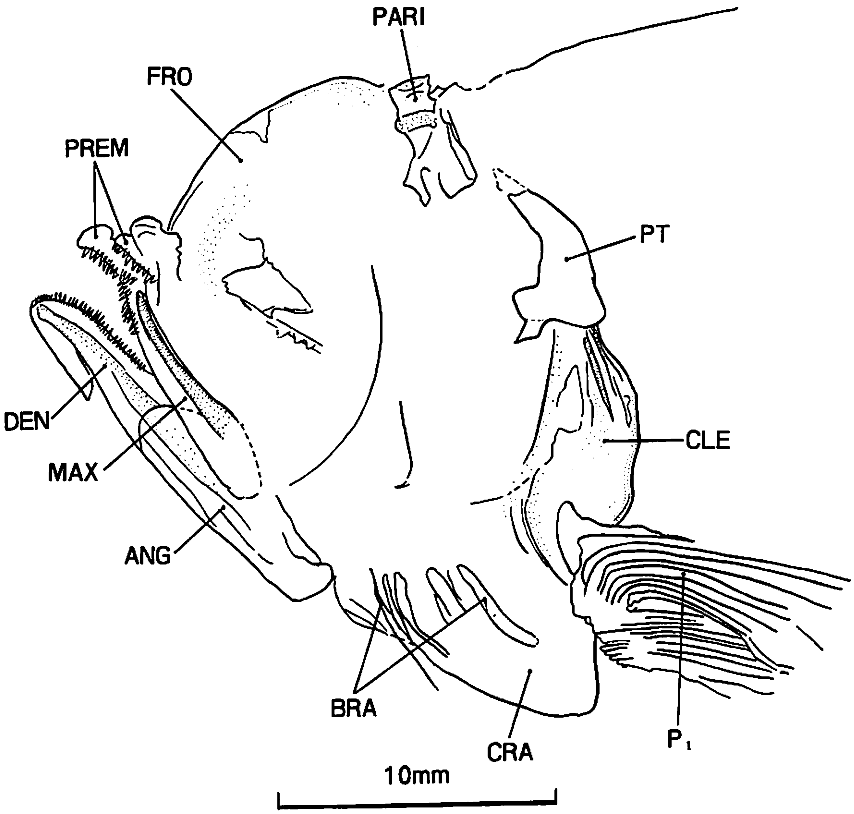

Fig. 42. *Aokiichthys otai* gen. et sp. nov., head region of the holotype, KMNH VP 100,173.

and second excavations of the Cretaceous fish fossils in Kitakyushu City.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Description of the holotype.

The body is deep. The body depth is contained 2.3 times in the standard length. The head length is contained 3.6 times in the standard length. The snout is rounded. The outline of the head dorsal margin is slightly convex. The outline from the occipital region to the dorsal origin is slightly convex (Fig. 40). The restored outline of the abdomen is convex, and runs little under the lower end of each rib (Fig. 41). The median fins are relatively posterior in position. The dorsal

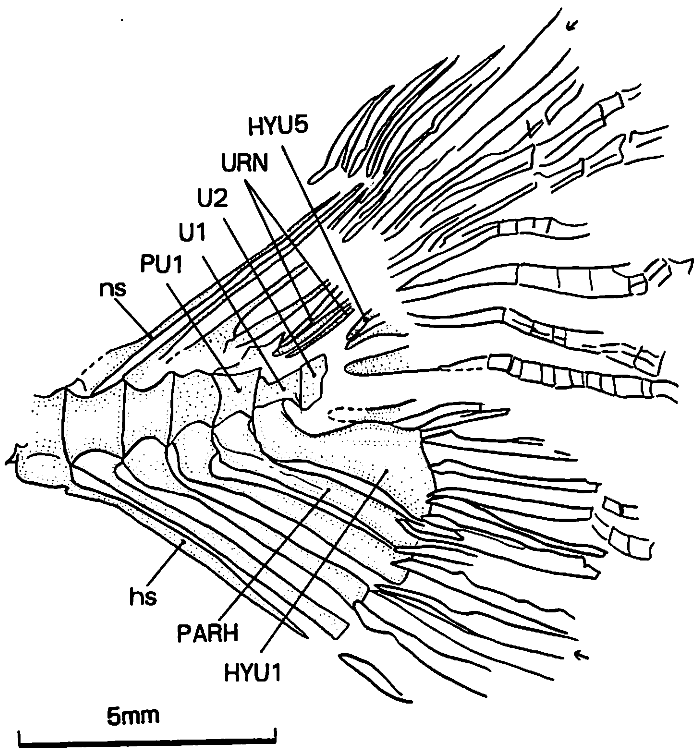

Fig. 43. *Aokiichthys otai* gen. et sp. nov., caudal region of the holotype, KMNH VP 100,173.

origin is vertical with the anal origin. The first dorsal fin pterygiophore is inserted between the first and second caudal vertebrae. The dorsal fin base is contained 1.9 times in the anal fin base. The pectoral fin elongates and extends over the pelvic insertion. The caudal fin is emarginate. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively. Sixteen pectoral fin rays are visible. Six pelvic fin rays are visible. There are 17 principal caudal fin rays (1,7,8,1). The gape of the mouth is large. The lower jaw is long and narrow. The dentary bears small canine like teeth on its oral margin. The suture between the dentary and anglo-articular is not visible and the posterior part of the lower jaw is poor in preservation. The premaxilla and maxilla bear small canine like teeth. Three large teeth are visible on the parasphenoid. The parasphenoid teeth are larger than the premaxillary, maxillary and dentary teeth. The premaxillary and maxillary teeth are slightly larger than the dentary teeth. Seven branchiostegal rays are visible (Fig. 42). The cleithrum is wide and has two ridges at the upper part.

The coracoid is low and round at the posterior margin. The posterior end of the lower jaw is placed almost below the posterior margin of the orbit. The parasphenoid tooth is not visible. There are villiform teeth on the endopterygoid. The palatine is slender and has minute teeth. The total number of vertebrae is 35, with 19 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae is estimated on the basis of the ribs. The number of ribs is 14. There is a series of median supraneurals behind the head and ending above the first caudal vertebra. Each supraneural from the first to the third is leaf-shape with a ridge running from a dorsal end to a ventral end. The other supraneurals are cylindrical. The first preural centrum bears the narrow parhypural. The neural arch and spine of the first preural centrum are separated each other. Five hypurals are visible. The first hypural is the largest. The second hypural is about one fifth of the first one in width. There is a space between the second and third hypurals. The second to fifth hypurals are slender. There are two ural centra. The second ural centrum bears at least three hypurals (HYU3–5). Three uroneurals are visible. The first uroneural extends forward to the first ural centrum. The epural is not visible (Fig. 43).

Description of the paratypes.

In KMNH VP 100,174, the body depth is contained 2.1 times in the standard length. The head length is contained 3.7 times in the standard length. The dorsal fin base is contained 1.8 times in the anal fin base. The number of principal dorsal fin rays is 12. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 19. The dentary bears small canine like teeth on its oral margin. The suture between the dentary and anglo-articular is not visible. Three large canine like teeth are visible on the parasphenoid at the posterior part of orbit. The total number of vertebrae is 36, with 19 caudal vertebrae.

In KMNH VP 100,175, the body depth is contained 2.4 times in the standard length. The head length is contained 3.2 times in the standard length. The dorsal fin base is contained 1.9 times in the anal fin base. The number of principal dorsal fin rays is 11. The number of principal anal fin rays is 19. There are 20 anal fin pterygiophores. The total number of vertebrae is 34, with 18 caudal vertebrae. The number of ribs is 14.

Remarks. This new species, *Aokiichthys otai,* resemble *Yungkangichthys hsitanensis* CHANG & CHOU, 1974 (Fig. 29) in having almost same number of dorsal and anal fin rays, and almost same proportion (Tab. 3). But it differs from *Y. hsitanensis* in having the smaller numbers of vertebrae. The number of vertebrae is 34 to 36 in *A. otai,* 44 in *Y. hsitanensis*. *A. otai* is closest to *Aokiichthys uyenoi* in having almost same meristic character and the proportion with the exception of the relative position of the median fins (Tab. 3). The origin of dorsal fin is vertical with the anal origin in *A.*

otai. The origin of dorsal fin is vertical with the fourth anal fin pterygiophore in *A. uyenoi*.

Aokiichthys uyenoi sp. nov.

(Figs. 44–47, Pl. 47)

Diagnosis. It differs from other species of the genus *Aokiichthys* in having the combination of following characters. Large teeth are present on the parasphenoid. The body is deep and the body depth is contained 2.1 to 2.5 times in the standard length. The median fins are relatively posterior in position. The dorsal origin is behind the anal origin and is vertical with the fourth anal fin pterygiophore. The number of principal dorsal fin rays is 9 to 11. The number of principal anal fin rays is 18 to 21. The range of size is 46.3 to 69.4 mm in standard length. The number of vertebrae is 34 to 35 with, 17 to 18 caudal vertebrae. The number of ribs is 14 to 15.

Holotype. KMNH VP 100,176, an almost complete specimen with its right side exposed. The standard length is 56.2 mm.

Paratypes. KMNH VP 100,177, an almost complete specimen with its right side exposed, with the counter part of the anterior part of the body, but the central part of the caudal skeleton is missing. The standard length is 59.4 mm. KMNH VP 100,178, an almost complete specimen with its left side exposed, but the caudal fin is missing. The standard length is 69.4 mm. KMNH VP 100,179, an almost complete specimen with its right side exposed. The standard length is 53.3 mm. KMNH VP 100,180, an almost complete specimen with its left sideexposed. The standard length is 61.9 mm. KMNH VP 100,181, an almost complete specimen with its right side exposed. The standard length is 46.3 mm. KMNH VP 100,182, an almost complete specimen with its left side exposed. The standard length is 65.5 mm.

Etymology. The species is named for Dr. Teruya UYENO, a ichthyologist who gave me many valuable advice for the present study and has contributed to the study of fish fossils in Japan.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

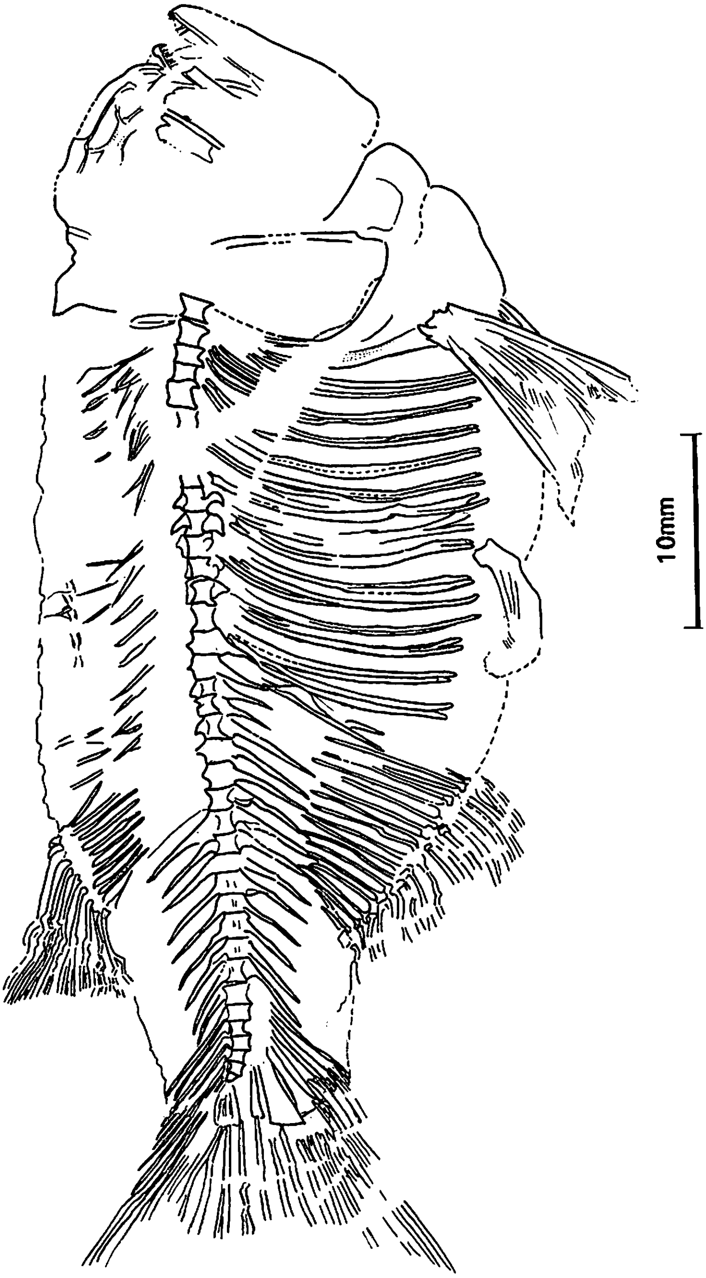

Fig. 44. *Aokiichthys uyenoi* gen. et sp. nov., the holotype, KMNH VP 100,176.

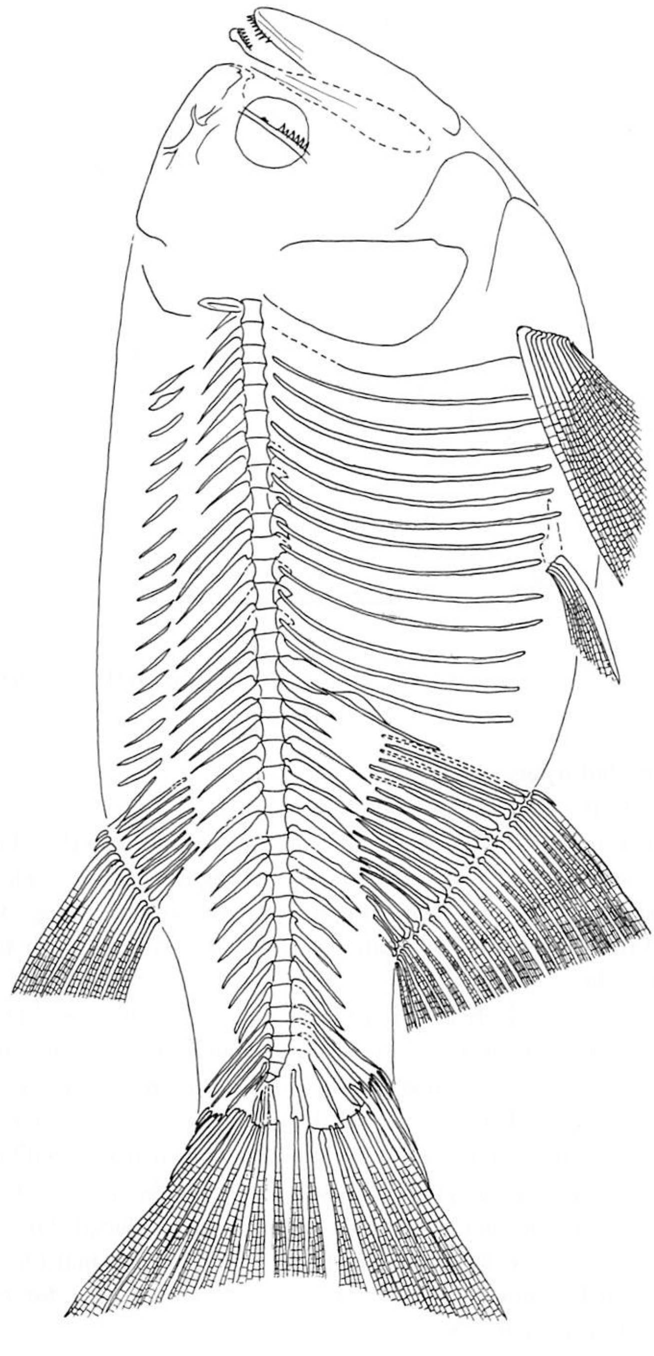

Fig. 45. *Aokiichthys uyenoi* gen. et sp. nov., restoration of the skeleton.

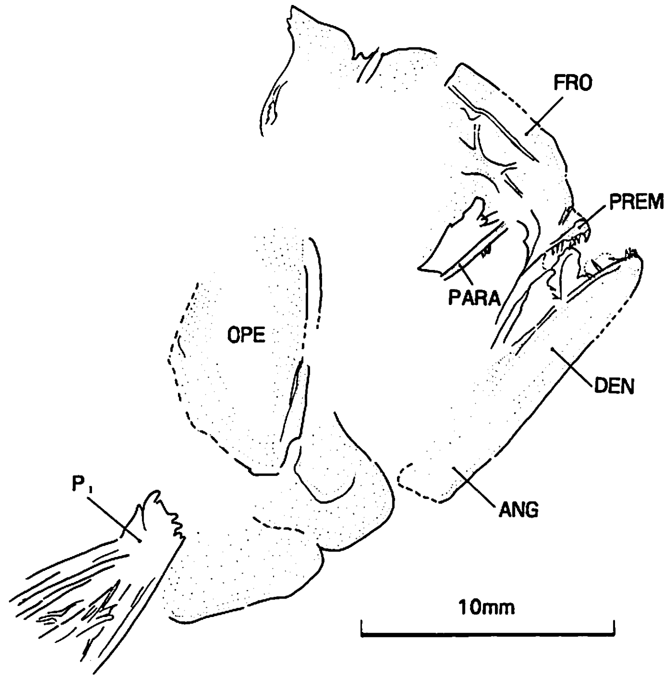

Fig. 46. *Aokiichthys uyenoi* gen. et sp. nov., head region of the holotype, KMNH VP 100,176.

Description of the holotype.

The body is deep. The body depth is contained 2.1 times in the standard length. The head length is contained 3.2 times in the standard length. The snout is rounded. The outline of the head dorsal margin is slightly convex. The outline from the occipital region to the dorsal origin is almost straight (Fig. 44). The restored outline of the abdomen is remarkably convex and runs little under the lower end of each rib (Fig. 45).

The median fins are relatively posterior in position. The dorsal origin is behind the anal origin and vertical with the fourth anal pterygiophore. The first dorsal fin pterygiophore is above the first caudal vertebra. The dorsal fin base is contained 2.3 times in the anal fin base. The pectoral fin elongates and extends over the pelvic insertion. The caudal fin is emarginate. The number of principal dorsal fin rays is 9. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 21. There are 20 anal fin pterygiophores. The principal dorsal fin rays are preceded by one small unbranched accessory ray. The principal anal fin rays are preceded by one small unbranched accessory ray. Seven pectoral fin rays are visible. There are 17 principal caudal fin rays (1,7,8,1).

The gape of the mouth is large. The lower jaw is long and narrow. The dentary bears small canine like teeth. The suture between the dentary and anglo-

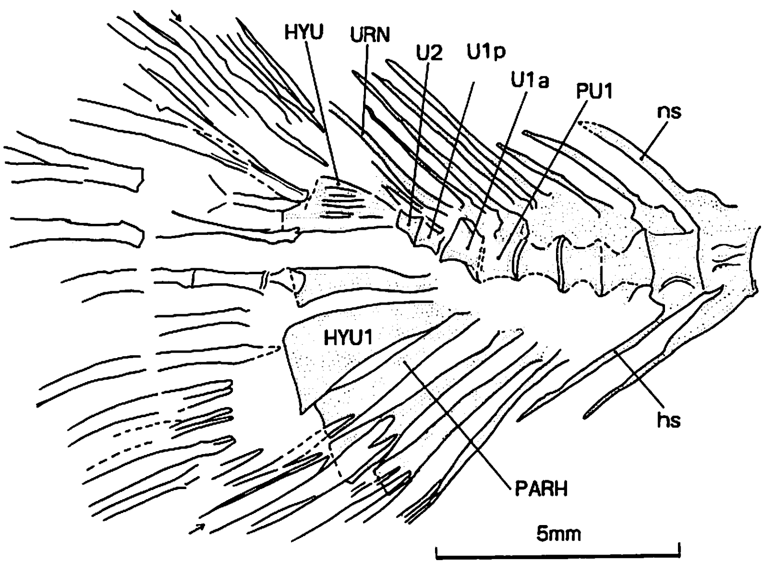

Fig. 47. *Aokiichthys uyenoi* gen. et sp. nov., caudal region of the holotype, KMNH VP 100,176.

articular is not visible and the posterior part of lower jaw is poor in preservation. The premaxilla bears small canine like teeth. The teeth of jaws are almost same in size. The posterior end of the lower jaw is placed below the posterior margin of the orbit. There are villiform teeth on the endopterygoid. The frontal is long and wide, and carries a superficial canal. The canal is separated at the posterior end. A part of the opercle is visible (Fig. 46).

The total number of vertebrae is 34, with 18 caudal vertebrae. The number of ribs is 14. There is a series of median supraneurals beginning immediately behind the head and ending above the first caudal vertebra. The first preural centrum bears the narrow parhypural. The neural arch and spine of the first preural centrum are complete. There are 7 hypurals. The first hypural is the largest. The second hypural is about one third of the first one in width. There is a space between the second and third hypurals. The third to seventh hypurals are slender. There are two ural centra. The anterior and posterior parts of the first ural centrum are present. The second ural centrum bears at least five hypurals (HYU3–7). Three uroneurals are visible. The first uroneural extends forward to the first ural centrum. The anterior ends of the uroneurals are not visible. The epural is not visible (Fig. 47).

Description of the paratypes.

In KMNH VP 100,177, the body depth is contained 2.5 times in the standard

length. The head length is contained 3.4 times in the standard length. The dorsal fin base is contained 2.3 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores. The number of pectoral fin rays is 10. The dentary bears small canine like teeth on its oral margin. The maxilla bears small teeth almost entirely on its oral margin. The palatine is slender and has minute teeth. The supramaxilla is present. One infraorbital is visible at the postero-ventral corner of the orbit and has a sensory canal along the orbital margin. The total number of vertebrae is 34, with 17 caudal vertebrae.

In KMNH VP 100,178, the body depth is contained 2.4 times in the standard length. The head length is contained 3.3 times in the standard length. The dorsal fin base is contained 1.8 times in the anal fin base. The number of principal dorsal fin rays is 10. There are 11 dorsal fin pterygiophores. The total number of vertebrae is 35, with 18 caudal vertebrae. The number of ribs is 15.

In KMNH VP 100,179, the body depth is contained 2.1 times in the standard length. The head length is contained 3.2 times in the standard length. The dorsal fin base is contained 1.9 times in the anal fin base. The number of principal dorsal fin rays is 11. Nine pectoral fin rays is visible. The total number of vertebrae is 35, with 18 caudal vertebrae. The number of ribs is 15.

In KMNH VP 100,180, the body depth is contained 2.2 times in the standard length. The head length is contained 3.7 times in the standard length. The first dorsal pterygiophore is above the second caudal vertebra. The dorsal fin base is contained 1.9 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 18. There are 18 anal fin pterygiophores.

In KMNH VP 100,181, the body depth is contained 2.1 times in the standard length. The head length is contained 3.4 times in the standard length. The dorsal fin base is contained 1.7 times in the anal fin base. The number of principal dorsal fin rays is 10. The number of principal anal fin rays is 20. There are 20 anal fin pterygiophores. The number of ribs is 15.

In KMNH VP 100,182, the body depth is contained 2.7 times in the standard length. The head length is contained 3.4 times in the standard length. The dorsal fin base is contained 2.1 times in the anal fin base. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores. Seven large canine like teeth are preserved at the posterior part of the orbit on the parasphenoid. The total number of vertebrae is 35, with 18 caudal vertebrae. The number of ribs is 15.

Remarks. *Aokiichthys uyenoi* is close to *Yungkangichthys hsitanensis* CHANG & CHOU, 1974 in having almost same number of dorsal and anal fin rays and almost same proportion (Tab. 3). But it differs from *Y. hsitanensis* in having the smaller number of

vertebrae. The number of vertebra is 34 to 35 in *A. uyenoi*, 44 in *Y. hsitanensis*. *A. uyenoi* is closest to *Aokiichthys otai* in having almost same meristic characters and almost same proportion with the exception of the relative position of the median fins (Tab. 3). The origin of the dorsal fin is vertical with the fourth anal fin pterygiophore in *A. uyenoi*. The origin of dorsal fin is vertical with the anal origin in *A. otai*.

Aokiichthys praedorsalis sp. nov.

(Figs. 48–50, pls. 48–49)

Diagnosis. It differs from other species of the genus *Aokiichthys* in having the combination of following characters. The dorsal fin is large. The anal origin is behind the dorsal origin and about vertical with the 7th dorsal fin pterygiophore (the middle of the dorsal fin base). The length of dorsal fin base is contained 1.2 times in the length of anal fin base. The number of dorsal fin rays is 11 to 13. The number of anal fin rays is 15 to 17. The parasphenoid teeth are larger than those of the premaxilla and the dentary. The length of lower jaw is contained 1.5 times in the head length. The known size is 57.7 to 146.7 mm.

Holotype. KMNH VP 100,155, an almost complete specimen, but a dorsal part of caudal peduncle is missing. The head and caudal skeletons are poorly preserved. The standard length is 146.7 mm.

Paratypes. KMNH VP 100,156, an anterior part of the body. The length from the anterior end of the premaxilla to the posterior end of the 20th vertebra is 82 mm. KMNH VP 100,157, an almost complete specimen with its right side exposed. The standard length is 61.8 mm. KMNH VP 100,158, an almost complete specimen, with its left side exposed. The standard length is 57.7 mm.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology: The species name, *praedorsalis*, means anterior position of the dorsal fin, which refers to the fact that the dorsal origin is situated before the anal fin in this species.

Description of the holotype.

The body is deep. The body depth is contained 2.8 times in the standard

length. The head length is contained 3.3 times in the standard length. The snout is pointed. The outline of the head dorsal margin is almost straight and slightly convex. The outline from the occipital region to the dorsal origin is almost straight. The restored outlined of the abdomen is slightly convex and runs little under the lower end of each rib. The premaxilla and dentary bear a row of canine like teeth. The third tooth on the premaxilla is the largest. The lower jaw is long and its posterior end is well behind the orbit. Three large canine like teeth are preserved almost center of the orbit on the parasphenoid. These teeth are larger than those of the premaxilla and the dentary (Fig. 48). A part of the opercle is preserved (Fig. 49). The numerous fine spoke-like ridges are present on the surface of the opercle. The median fins are relatively posterior in position. There are 13 dorsal fin rays and 12 pterygiophores. The dorsal origin is slightly before the anal origin. The dorsal fin base is shorter than the anal fin base. The end of dorsal fin base is about vertical with the 8th anal fin pterygiophore (the middle of the anal fin base). There are 17

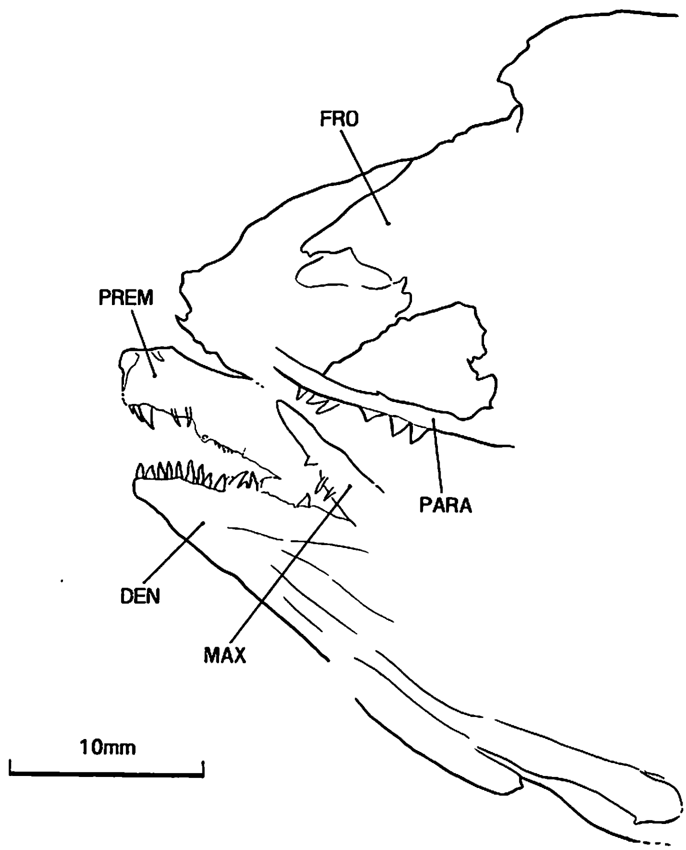

Fig. 48. *Aokiichthys praedorsalis* gen. et sp. nov., head region of the holotype, KMNH VP 100,155.

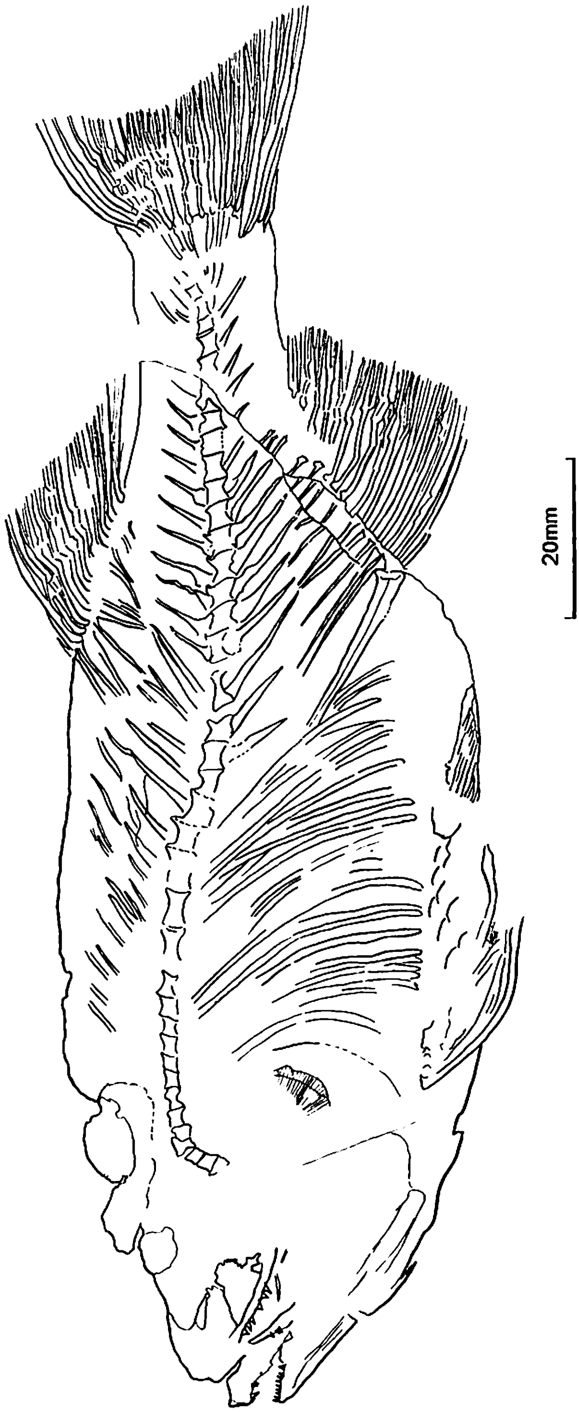

Fig. 49. *Aokiichthys praedorsalis* gen. et sp. nov., the holotype, KMNH VP 100,155.

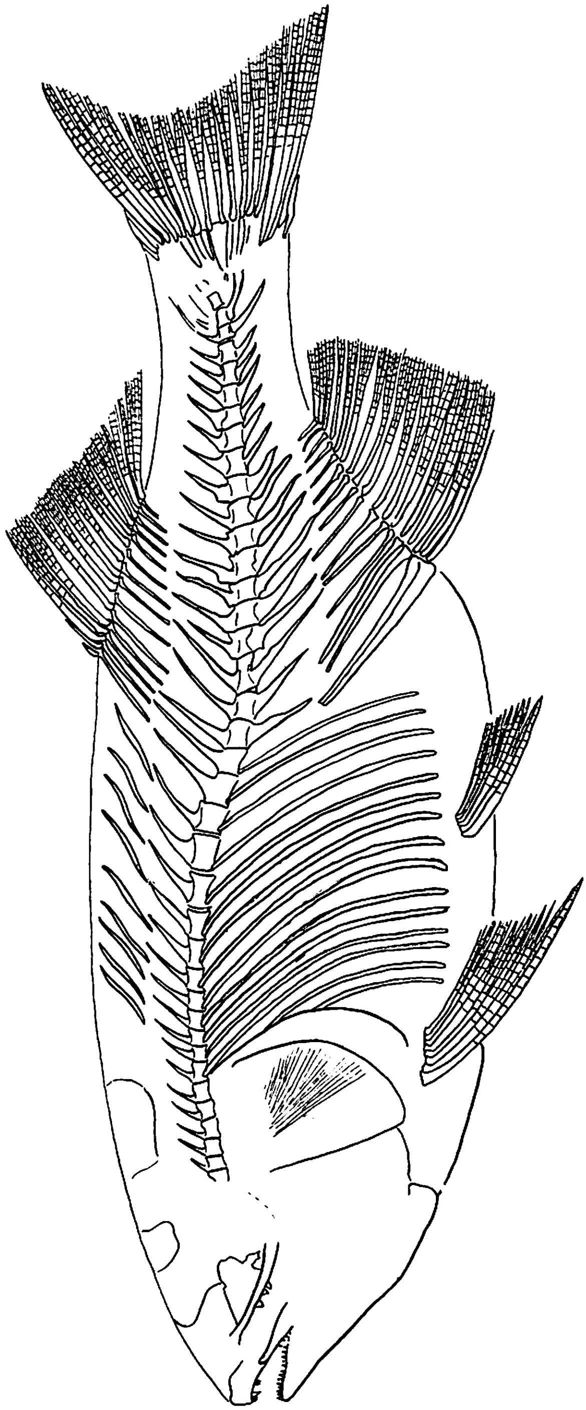

Fig. 50. *Aokiichthys praedorsalis* gen. et sp. nov., restoration of the skeleton.

anal fin rays and 16 pterygiophores. The pectoral fin reaches the pelvic insertion. The first ray of pectoral fin is stout and long. The caudal fin is emarginate. The number of branched caudal fin rays is 15 (1,7,8,1). The number of vertebrae is 36, with 18 caudal vertebrae. The anterior 10 vertebrae are small.

Description of the paratype.

In KMNH VP 100,156, nine long canine like teeth on the dentary are visible. There are 7 teeth similar to the dentary teeth on the premaxilla. Four large canine like teeth on the parasphenoid and the teeth are more stout than the dentary and the premaxillary teeth. Eleven branchiostegal rays are visible. The number of pectoral fin rays is 10. Sixteen ribs can be counted.

In KMNH VP 100,157, the body depth is contained 2.7 times in the standard length. The head length is contained 3.6 times in the standard length. The dorsal fin base is contained 2.0 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 15. There are 15 anal fin pterygiophores. The total number of vertebrae is 35, with 18 caudal vertebrae. The number of ribs is 15.

In KMNH VP 100,158, the body depth is contained 2.8 times in the standard length. The head length is contained 3.5 times in the standard length. The dorsal fin base is contained 1.7 times in the anal fin base. The number of principal anal fin rays is 17. There are 17 anal fin pterygiophores. Nine pectoral fin rays are visible. The total number of vertebrae is 35, with 18 caudal vertebrae. The number of ribs is 15.

Remarks. This new species differs from other species of the genus, *Aokiichthys* in having the former position of the dorsal fin, the large dorsal fin, the largest number of the dorsal fin rays and the fewest number of the anal fin rays. The anal origin is behind the dorsal origin and about vertical with the 7th dorsal fin pterygiophore (the middle of the dorsal base). The length of dorsal fin base is contained 1.2 times in the length of anal fin base. The number of dorsal fin rays is 11 to 13. The number of anal fin rays is 15 to 17. The standard length of the largest specimen, holotype is 146.7 mm. This is the largest in the genus *Aokiichthys*.

Aokiichthys sp.

(Fig. 51, Pl. 49)

Specimen. KMNH VP 100,159, the anterior part of the body. The posterior part of the abdomen and the caudal part of the body are missing.

Locality. Tokuriki (TO-1), Kokura-minami-ku (Kokura Southern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The First Formation (the lower formation, W_1, correlated to the Sengoku Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Description.

The snout is rounded. The outline of the head dorsal margin is slightly convex. The pectoral fin rays and the pelvic fin rays are visible. The gape of the mouth is large. The lower jaw is long and narrow. The dentary bears large canine like teeth. The suture between the dentary and the anglo-articular is not visible. The premaxilla and the maxilla bear large canine like teeth. The teeth of jaws are almost same in size. The posterior end of the lower jaw is placed behind the orbit. Eight canine like teeth are preserved on the parasphenoid at about center of the orbit. The parasphenoid teeth are almost same with the teeth of jaws in size. There are villiform teeth on the endopterygoid. There is a series of median supraneurals. The supraneurals are cylindrical.

Remarks. This species differs from other species of the genus, *Aokiichthys*, in having the combination of following characters. The snout is rounded. The length of

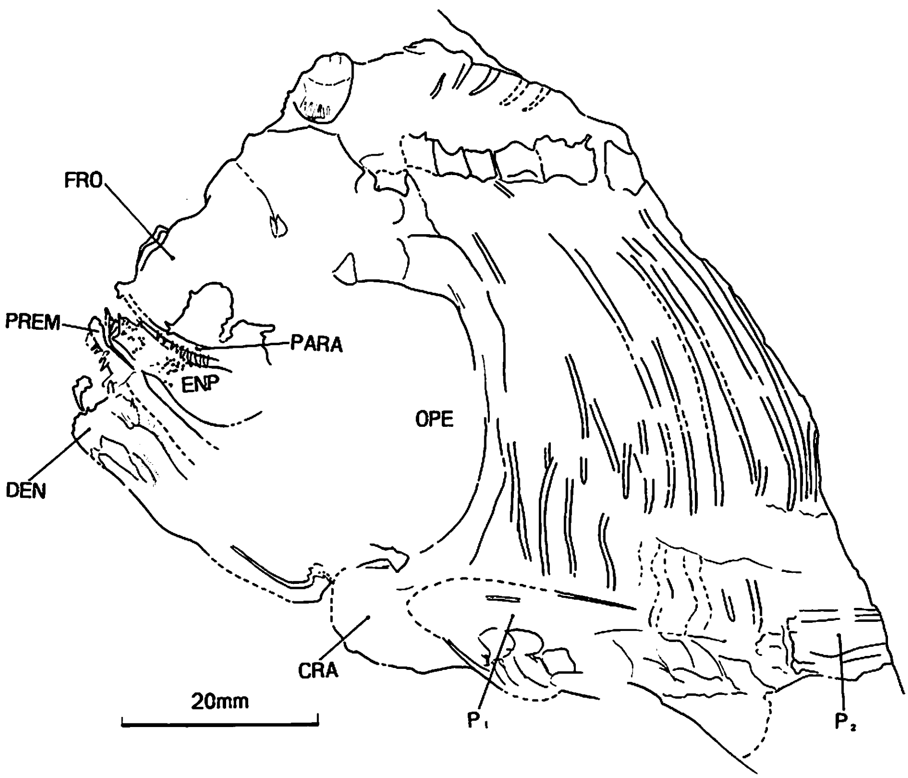

Fig. 51. *Aokiichthys* sp., KMNH VP 100,159.

lower jaw is contained 1.3 times in the head length. The parasphenoid teeth are almost same with the teeth of jaws in size. The position of pelvic fin indicates the deep body (Fig. 51). The present author does not describe it as a new species, because the specimen is too incomplete.

Family Wakinoichthiidae nov.

Diagnosis. This new family differs from other families of the Osteoglossiformes in the following combination of characters. The body is slender, and the body depth is contained 6 times or more in the standard length. The head length is contained 4 times or more in the standard length. The long pectoral fin extends beyond the pelvic fin insertion. The gape of the mouth is large and the lower jaw is long with small canine-like teeth on the dentary. Large teeth are absent on the parasphenoid. The frontals are long and narrow. The number of principal caudal fin rays is 18 (1,8,8,1). The number of hypurals is 7. The first uroneural does not extend to the second preural centrum. Two parts of the first ural centrum are present. The neural arch and spine of the first preural centrum are complete. The number of vertebrae is 48. The median supraneurals are broad. The dorsal origin is behind the anal origin. The dorsal fin base is about half of the anal fin base. The end of the dorsal fin base does not reach the end of the anal fin base.

Genus ***Wakinoichthys*** **gen. nov.**

Diagnosis. As for the family, monotypic genus.

Type species. *Wakinoichthys aokii* sp. nov.

Etymology. The generic name, *Wakinoichthys* consists of *Wakino*, the name of the formation in which the type specimen was yielded, and *ichthys*, a Greek word meaning fish.

Remarks. The presence of the parasphenoid teeth is not clear (at least large teeth are absent on the parasphenoid), but the following combination of characters indicate that the Wakinoichthiidae is a member of the teleostean fish order Osteoglossiformes: 1) the median fins are relatively posterior in position, 2) the premaxilla and dentary have canine like teeth, 3) the endopterygoid has villiform teeth, 4)the pectoral fin elongates, 5) the series of supraneurals are present, 6) the anterior and the posterior parts of the first ural centrum are present, 7) the straplike uroneurals are present, 8) the number of hypural is seven, 9) the neural arch and spine of the first preural centrum are complete, 10) the number of principal caudal fin rays is 18.

Seven families and about twenty genera of the Osteoglossomorpha are known

from Upper Jurassic to Recent in Africa, America, East Indies, Australia and Asia. Among them, most of Mesozoic genera (excepting *Chandlerichthys* from Middle Cretaceous deposits of North America by GRANDE, 1986) are known from Upper Jurassic to Lower Cretaceous time in eastern Asia. These are *Lycoptera, Asiatolepis, Paralycoptera, Yanbiania, Yungkangichthys, Tongxinichthys, Plesiolycoptera,* and *Kuyangichthys* (TAKAI, 1943; LIU H.-T. *et al.*, 1963; CHANG and CHOU, 1974, 1976, 1977, 1986; MA, 1980; LIU H.-T. *et al.*, 1982; LI, 1987). Among these Mesozoic genera, *Wakinoichthys* is closer to *Lycoptera* of the family Lycopteridae in having a slender body, the posterior position of the median fins, a series of leaf-shape supraneurals, and especially its caudal skeleton with seven hypurals, two parts of the first ural centrum, and the complete neural arch and spine of the first preural centrum which were described by GREENWOOD (1970). But *Wakinoichthys* differs from *Lycoptera* in having the following characters. There are no large teeth on the parasphenoid. The dorsal origin is behind the anal origin. The dorsal fin base is about half of the long anal fin base. The pectoral fin elongates. The centra are well ossified. In the caudal skeleton, *Wakinoichthys* is similar to the hiodontid genus *Eohiodon* from Eocene deposits of North America (CAVENDER, 1966; GRANDE, 1979; WILSON, 1978) and *Hiodon* of Recent in North America, but differs in having no large teeth on the parasphenoid and the long pectoral fin.

The long pectoral fin of *Wakinoichthys* is similar to that of the osteoglossoid *Singida* from ?Paleocene of East Africa (GREENWOOD and PATTERSON, 1967), *Phareodus* from Eocene of North America (COPE, 1883; GRANDE, 1980) and the extant genera (*Osteoglossum* in South America and *Scleropages* in northern Australia and Southeast Asia). But these osteoglossoid genera differ from *Wakinoichthys* with their caudal skeleton. There are five hypurals in *Singida* and six hypurals in *Phareodus, Scleropages* and *Osteoglossum* (hypurals 3 to 6 fused in *Osteoglossum*) and no uroneurals in *Phareodus, Scleropages* and *Osteoglossum*. The first ural centrum is not separated in these osteoglossoid genera (GREENWOOD, 1967; GREENWOOD and PATTERSON, 1967).

Wakinoichthys is similar to two genera of the family Huashiidae, *Huashia* from Late Jurassic-Early Cretaceous deposits of Zhejiang Province in China (CHANG and CHOU, 1974, 1977) and *Kuntulunia* from Early Cretaceous deposits of Nei Mongol and Nigxia Province in China (LIU *et al*, 1982, 1985; ZHANG, 1990), in the position of median fins, having no large teeth on the parasphenoid and wide supraneurals, but differs in having the slender body, the long pectoral fin, the long and narrow frontals, the large gape of the mouth, seven hypurals, two parts of the first ural centrum and the uroneural not reaching to the second preural centrum. CHANG and CHOU (1977, 1986) considered that *Huashia* is related to the Chanidae. LIU *et al* (1985) and ZHANG (1990) referred the Huashiidae to Osteoglossiformes.

The caudal skeleton of *Wakinoichthys* indicates that the genus is closely related to those of the hiodontoid families Lycopteridae and Hiodontidae, which are included within the suborder Notopteroidei, but *Wakinoichthys* differs from them in having no

large teeth on the parasphenoid. Genera of Notopteridae of the other superfamily (Notopteroidea) differs from *Wakinoichthys* in having a long anal fin confluent with a reduced caudal fin.

Wakinoichthys aokii sp. nov.

(Figs. 52–59, Pls. 50–51)

Diagnosis. It differs from other species in having the combination of following characters. The estimated range of size is 70 to 120 mm in standard length (The estimated maximum standard length is 120 mm in the paratype, KMNH VP 100,143.). The body depth is contained 6.4 times in the standard length. The head length is contained 4.4 times in the standard length. The dorsal origin is about vertical with the anterior one fourth of the anal base. The number of principal dorsal fin rays is 10 to 12. There are 10 to 12 dorsal fin pterygiophores and a stay. The number of principal anal fin rays is 20 to 22. There are 19 to 21 anal fin pterygiophores. The total number of vertebrae is 45 to 49, with 24 to 25 caudal vertebrae. The number of ribs is 22 to 23.

Holotype. KMNH VP 100,140, a nearly complete specimen from the Fourth Formation. The pelvic fin is missing. The standard length is 70.4 mm.

Paratypes from the Fourth Formation. KMNH VP 100,141, a nearly complete specimen. The standard length is 104.8 mm. KMNH VP 100,142, a specimen missing the head region. The length from the pectoral insertion to the posterior end of the hypural is 69.5 mm. KMNH VP 100,143, a specimen missing the anterior part of the head region. The length from the pectoral insertion to the posterior end of the hypural is 85.5 mm.
Paratypes from the Third Formation at Minamigaoka (KM-1). KMNH VP 100,184, an almost complete specimen, with its right side exposed, but the upper lob of caudal fin and the anterior end of the dentary are missing. The standard length is 59.7 mm. KMNH VP 100,185, an almost complete specimen with its right side exposed, but the anterior part of the head is missing. The length between the pectoral insertion and the end of the hypural is 41.0 mm. KMNH VP 100,186, a specimen with its left side exposed. The posterior part of the caudal bones is missing. The body slightly bents at the middle. The length from the snout to the posterior margin of the first preural centrum is 66.0 mm. KMNH VP 100,187, an almost complete specimen with its right side exposed, but the body strongly bents and the part from the posterior dorsal fin base to the posterior anal fin base is missing.

Locality. Kumagai (KA-0, KD-34) and Minamigaoka (KM-1), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The horizon at Kumagai is the Fourth Formation (the uppermost formation, W_4, correlated to the Upper Wakamiya Formation) and the horizon of Minamigaoka is the Third Formation (the upper formation, W_3, correlated to the Lower Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species is named for Mr. Tateyu AOKI, who collected and donated the specimens to the Kitakyushu Museum and Institute of Natural History.

Description of the holotype.

The body is slender and the body depth is contained 6.4 times in the standard length. The head length is contained 4.4 times in the standard length. The median fins are relatively posterior in position. The dorsal origin is behind the anal origin and about vertical with the anterior one fourth of the anal base. The first dorsal fin pterygiophore is inserted between the fourth and fifth caudal vertebrae. The dorsal fin base is about half of the anal fin base. The pectoral fin elongates and extends over the middle of the abdomen. The pelvic fin is not preserved on the holotype. The caudal fin is forked. The number of principal dorsal fin rays is 11. There are 12 dorsal fin pterygiophores and a stay. The number of principal anal fin rays is 22. There are 21 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by three small unbranched accessory rays respectively. Twelve pectoral fin rays are visible. The total number of vertebrae is 48, with 23 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae was estimated on the basis of the ribs. The number of ribs is 23. There is a series of median supraneurals beginning immediately behind the head and ending above the first caudal vertebra. Each supraneural of the anterior two-thirds is wide and leaf-shape with a ridge running from a dorso-posterior corner to an anteroventral corner (Fig. 52).

The gape of the mouth is large. The lower jaw is long. The dentary bears small canine like teeth on its oral margin. The suture between the dentary and anglo-articular is not visible and the posterior part of the lower jaw is poorly preserved. The mandibular sensory canal runs within the dentary. The premaxilla has canine like teeth which are larger than those of the dentary. The posterior end of the lower jaw is placed below the center of the orbit. The maxilla is not visible. There are villiform teeth on the endopterygoid. Teeth are not visible on the parasphenoid. The frontal is long and carries a superficial long groove (Fig. 54).

The first preural centrum bears the narrow parhypural. The neural arch and spine of the first preural centrum are complete. There are seven hypurals. The first hypural is the largest. The second hypural is about half of the width of the first one in width. There is a space between the second and the third hypurals. The

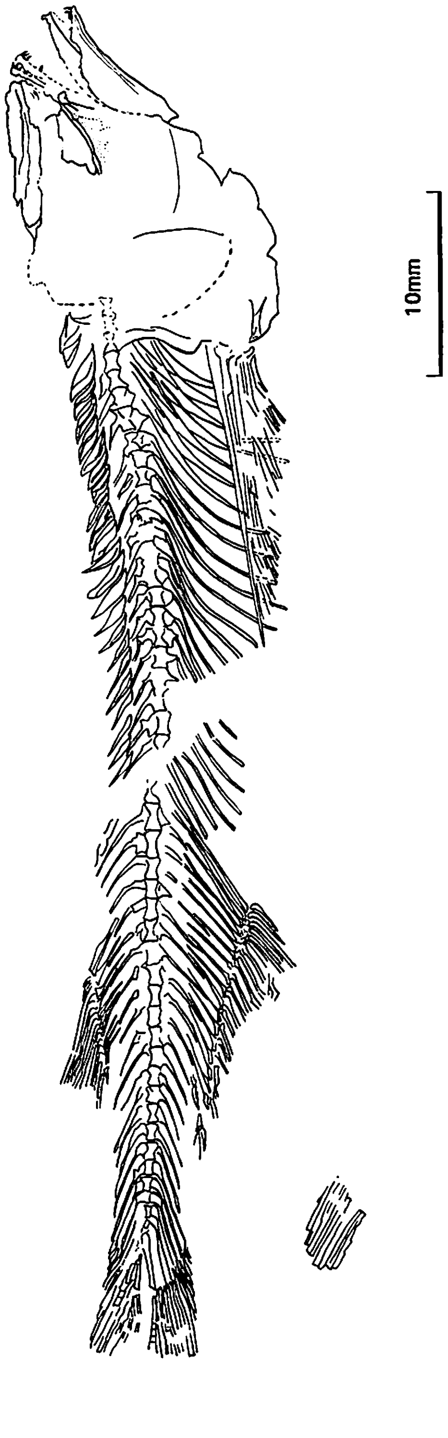

Fig. 52. *Wakinoichthys aokii* gen. et. sp. nov., the holotype, KMNH VP100,140, from the Fourth Formation.

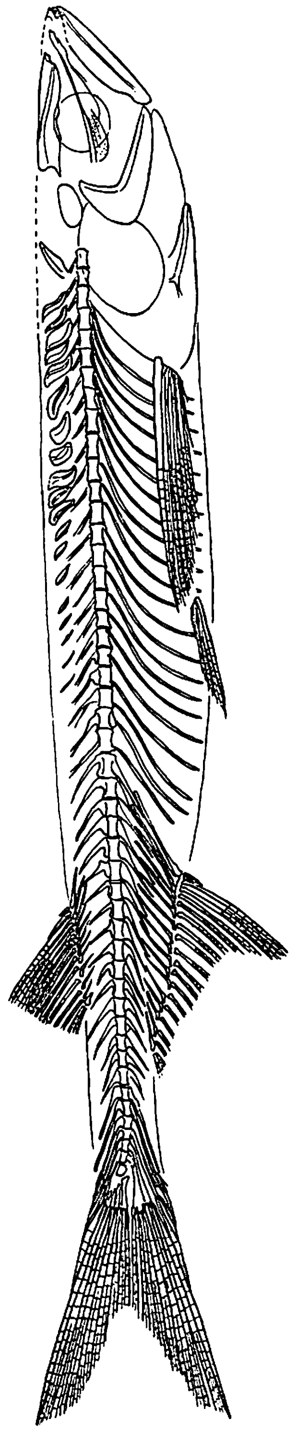

Fig. 53. *Wakinoichthys aokii* gen. et sp. nov., restoration of the skeleton.

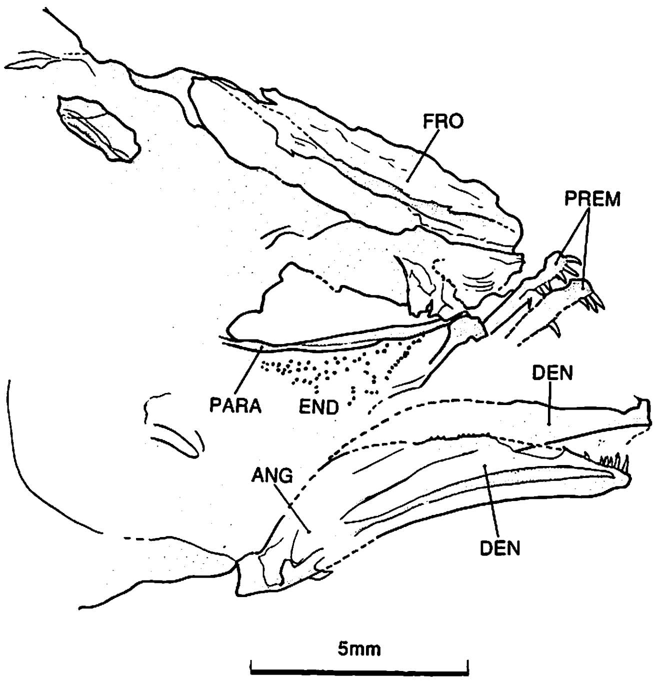

Fig. 54. *Wakinoichthys aokii* gen. et sp. nov., head region of the holotype, KMNH VP100,140.

third to seventh hypurals are slender and cylindrical. The second ural centrum bears at least three hypurals (HYU3–5). Whether the first ural centrum was separated is unknown. Three uroneurals are visible. The first uroneural extends forward to the first preural centrum. Epural is not visible. There are 18 principal caudal fin rays (1,8,8,1) (Fig. 55).

Description of the paratypes from the Fourth Formation.

In KMNH VP 100,141, the number of principal dorsal fin rays is 10. There are 10 dorsal fin pterygiophores. The number of principal anal fin rays is 22. There are 21 anal fin pterygiophores and a stay. The pelvic fin is slightly anterior to the middle of the abdomen. The long pectoral fin extends posterior to the pelvic fin insertion. The anterior and the posterior parts of the first ural centrum are present. Four uroneurals are visible (Fig. 56).

In KMNH VP 100,142, there is 12 dorsal fin pterygiophores and a stay. The number of principal anal fin rays is 21. There are 21 anal fin pterygiophores. The pelvic fin is present. The pectoral fin extends over the pelvic fin insertion.

In KMNH VP 100,143, the number of dorsal fin pterygiophores is 10. There are 20 principal anal fin rays and 19 anal fin pterygiophores. The pectoral fin extends over the pelvic fin insertion. This is the largest specimen.

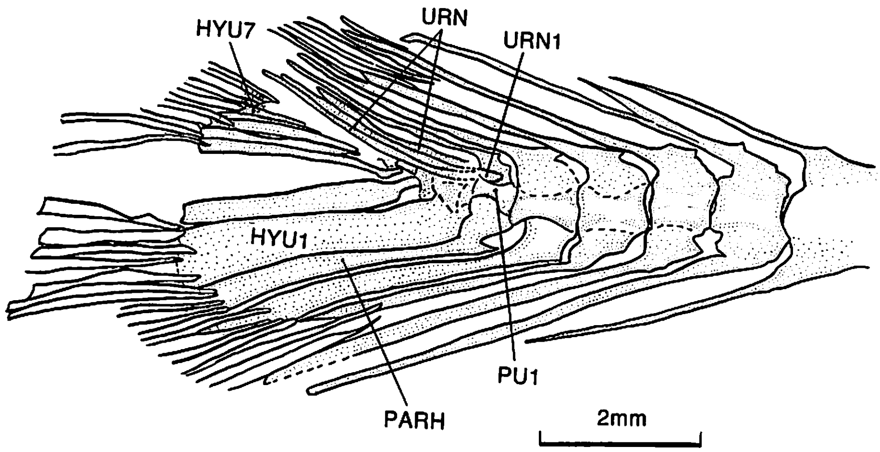

Fig. 55. *Wakinoichthys aokii* gen. et sp. nov., caudal skeleton of the holotype, KMNH VP100,140.

Description of the paratypes from the Third Formation.

In KMNH VP 100,184, the body is slender. The body depth is contained 6.3 times in the standard length. The head length is contained 5.5 times in the standard length. The snout is pointed. The outline of the head dorsal margin is almost straight. The outline from the occipital region to the dorsal origin is almost straight. The restored outline of the abdomen is almost strait and runs little under the lower end of each rib. The median fins are relatively posterior in position. The dorsal origin is behind the anal origin and about vertical with the anterior one fifth of the anal fin base. The first dorsal pterygiophore is inserted between the neural spines of the fourth and fifth caudal vertebrae (Fig. 57). The dorsal fin base is contained 1.6 times in the anal fin base. The pectoral fin elongates and extends beyond the middle of the abdomen and the pelvic insertion. The caudal fin is forked. The number of principal dorsal fin rays is 12. There are 12 dorsal fin pterygiophores and a stay. The number of principal anal fin rays is 18. There are 17 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively. Ten pectoral fin rays and five pelvic fin rays are visible. There are 18 principal caudal fin rays (1,8,8,1). The gape of the mouth is large. The mandible is long and narrow. The premaxilla, maxilla and the anterior part of the dentary are not visible. The posterior end of the mandible is placed below almost center of the orbit. There are no teeth on the parasphenoid. There are villiform teeth on the endopterygoid. The frontal is long and carries a superficial long canal. The outlines of the opercle and preopercle are visible (Fig. 58). The total number of vertebrae is 46, with 22 caudal vertebrae. The number of ribs is 22. There is a series of median supraneurals beginning close behind the head and ending

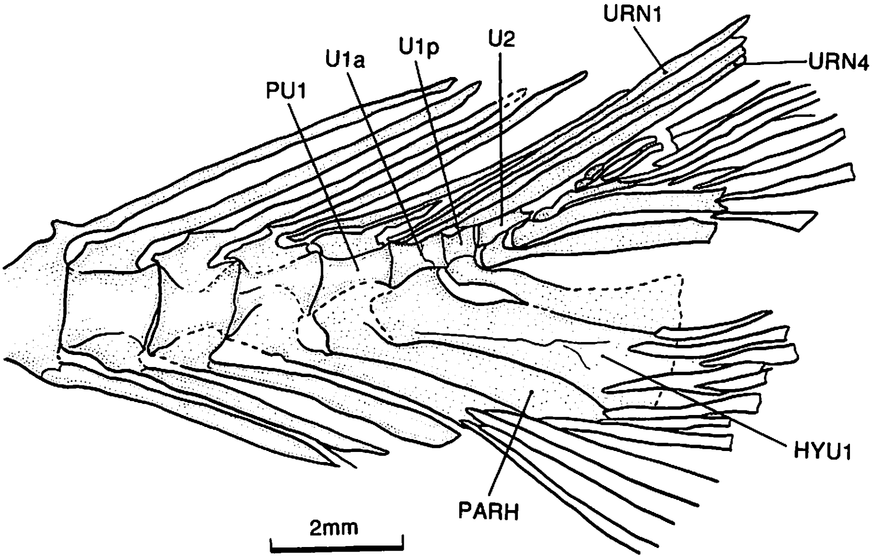

Fig. 56. *Wakinoichthys aokii* gen. et sp. nov., caudal skeleton of the paratype, KMNH VP100,141.

above the 21th abdominal vertebra. Three posterior supraneurals are cylindrical and the other supraneurals are wide and leaf-shape with a ridge running from a dorsal end to a ventral end. The first preural centrum bears the wide parhypural. The neural arch and spine of the first preural centrum are complete. Four hypurals are visible. The first hypural is the largest. The second hypural is cylindrical and about one third of the first one in width. There is a space between the second and the third hypurals. The third hypural is slender and cylindrical. There are two ural centra. One uroneural is visible. The anterior ends of uroneurals are not visible. Epurals are not visible (Fig. 59).

In KMNH VP 100,185, the first dorsal fin pterygiophore is inserted between the neural spines of the fifth and sixth caudal vertebrae. The dorsal fin base is contained 2.2 times in the anal fin base. The number of principal dorsal fin rays is 12. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 20. There are 20 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively. Ten pectoral fin rays are visible. There are 18 principal caudal fin rays (1,8,8,1). The total number of vertebrae is 49, with 24 caudal vertebrae. The number of ribs is 23. There are two ural centra. The first ural centrum is larger. The first and the second hypurals are attached to the first ural centrum. The first hypural is slightly larger than the second hypural. Five hypurals are present.

In KMNH VP 100,186, the first dorsal fin pterygiophore is between the sixth

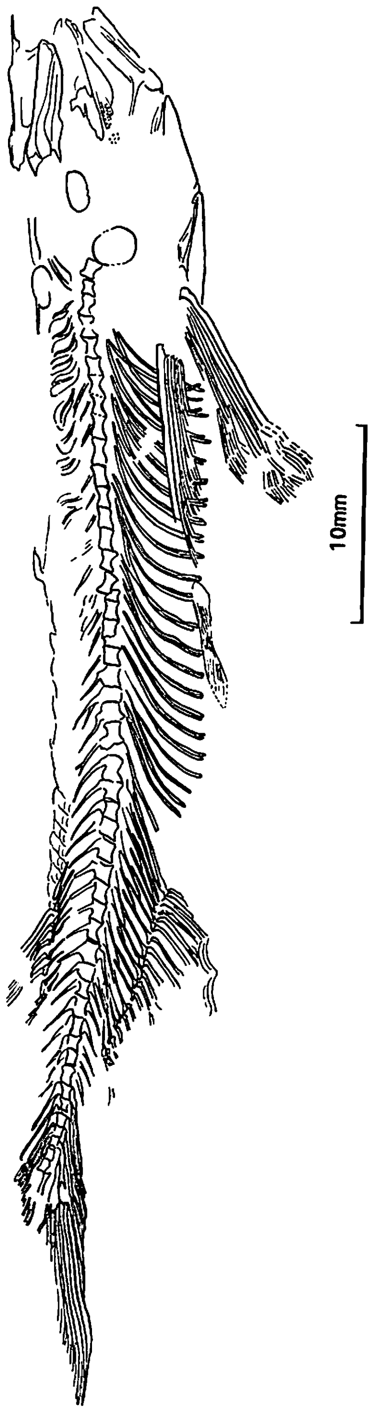

Fig. 57. *Wakinoichthys aokii* gen. et sp. nov., KMNH VP 100,184, from the Third Formation.

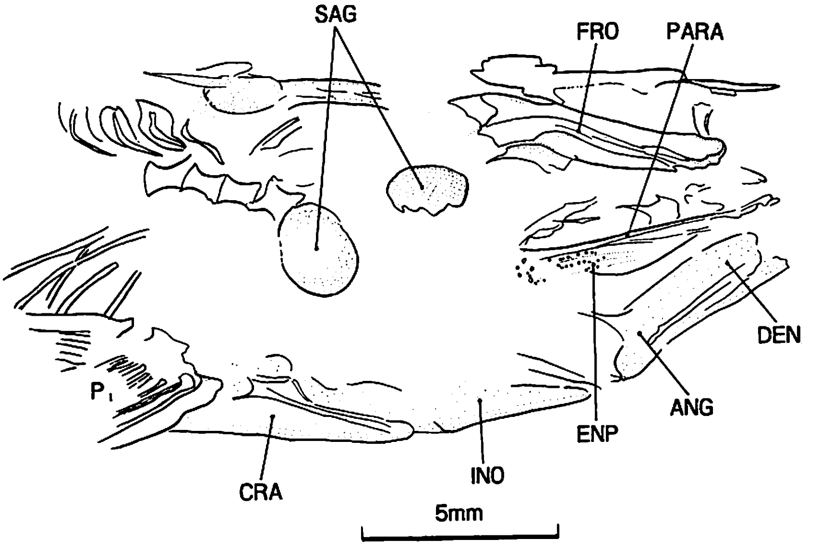

Fig. 58. *Wakinoichthys aokii* gen. et sp. nov., head region of the specimen, KMNH VP 100,184.

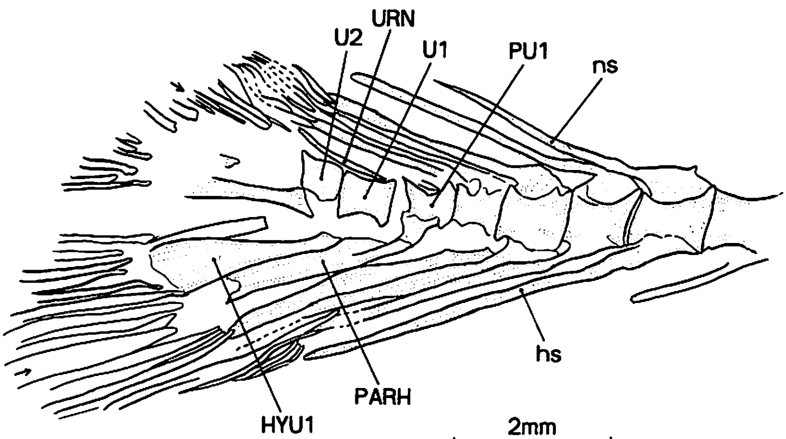

Fig. 59. *Wakinoichthys aokii* gen. et sp. nov., caudal region of the specimen, KMNH VP 100,184.

and the seventh caudal vertebra. The dorsal fin base is contained 1.9 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 18. There are 18 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively. Eleven pectoral fin rays are visible. Six pelvic fin rays are visible. The total number of vertebrae is 47, with 22 caudal

vertebrae. The number of ribs is 23.

In KMNH VP 100,187, the body depth is contained 4.5 times in the standard length. The head length is contained 3.2 times in the standard length. The first dorsal fin pterygiophore is between the neural spines of the sixth and seventh caudal vertebrae. Ten pectoral fin rays are visible. The total number of vertebrae is 45, with 21 caudal vertebrae. The number of ribs is 22. Each supraneural is cylindrical. There are two ural centra. One epural is visible. Six hypurals are visible. Three uroneurals are present. The first uroneural extends above the anterior part of the first preural vertebra.

Remarks. *Wakinoichthys aokii* are yielded from the Third Formation at Minamigaoka (KM-1) and the Fourth Formation at Kumagai (KA-0 and KD-34), Kokura-kita-ku (Kokura Northern Ward). The present author could not recognize the difference between these specimens from both formations with the exception of the small difference in the number of anal fin rays (Tab. 4).

Table 4. Comparison of characters in the species of the new genus *Wakinoichthys*.

	Wakinoichthys aokii gen. et sp. nov. from the Fourth Formation	*W. aokii* gen. et sp. nov. from the Third Formation	*W. robustus* gen. et sp. nov.
count			
D.	10–12	11–12	10
D. pterygiophore	10–12	11–12	11
A.	20–22	18–20	19–20
A. pterygiophore	19–21	17–20	19–22
V.	46–48 (24–25+22–23)	45–49 (24–25+21–24)	45–47 (23–25+22)
ribs	22–23	22–23	21–23
ratio			
SL/BL	6.4	4.5–6.3	3.5–3.8
SL/HL	4.4	3.2–5.5	3.2–3.9
other characters			
First dorsal fin pterygiophore inserted	5th and 6th of caudal vertebrae	4th and 5th or 5th and 6th	5th and 6th or 6th and 7th
Pectoral fin extended	beyond the pelvic insertion	beyond the pelvic insertion	the pelvic insertion

A., anal fin rays; BD, body depth; D., dorsal fin rays; HL, head length; SL, standard length; V., vertebrae.

Wakinoichthys robustus sp. nov.

(Figs. 60–63, Pl. 52)

Diagnosis. It differs from other species of the genus *Wakinoichthys* in having the

combination of following characters. The body depth is contained 3.5 to 3.8 times in the standard length. The head length is contained 3.2 to 3.9 times in the standard length. The number of vertebrae is 45 to 47, with 22 caudal vertebrae. The number of ribs is 19 to 23.

Holotype. KMNH VP 100,188, an almost complete specimen, with its right side exposed, but the middle of the body is slightly moved. The standard length is 38.6 mm.

Paratypes. KMNH VP 100,189, an almost complete specimen, with its left side exposed, but the anterior part of mandible is missing. The standard length is 31.8 mm. KMNH VP 100,190, an almost complete specimen, with its right side exposed, but the anterior end of the head region and the posterior part of the body are missing. The body bents at the middle. The length from the pectoral insertion to the anal origin is 13.8 mm. KMNH VP 100,191, a specimen with its right side exposed. The head and the anterior part of the abdomen are missing. The body bents at the middle. The length from the anal origin to the end of the hypural is 16.2 mm.

Locality. Minamigaoka (KM-1), Kokura-kita-ku (Kokura Northern Ward), Kita-kyushu City, Fukuoka Prefecture, Japan.

Horizon. The Third Formation (the upper formation, W_3, correlated to the Lower Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species name, *robustus*, means strong or robust, which refers to the fact that the body depth of this species deeper than that of *W. aokii*.

Description of the holotype.

The body is moderate. The body depth is contained 3.8 times in the standard length. The head length is contained 3.9 times in the standard length. The outline of the head dorsal margin is slightly convex. The outline from the occipital region to the dorsal origin is slightly convex (Fig. 60). The restored outline of the abdomen is slightly convex (Fig. 61). Median fins are relatively posterior in position. The dorsal origin is behind the anal origin and about vertical with the 13th anal fin pterygiophore (the anterior two-thirds of the anal fin base). The first dorsal pterygiophore is inserted between the 5th and the 6th caudal vertebrae. The dorsal fin base is contained 2.8 times in the anal fin base. The pectoral fin is long and reaches the pelvic insertion. The caudal fin is forked. The number of principal dorsal fin rays is 10. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 20. There are 19 anal fin pterygiophores. Ten pectoral fin

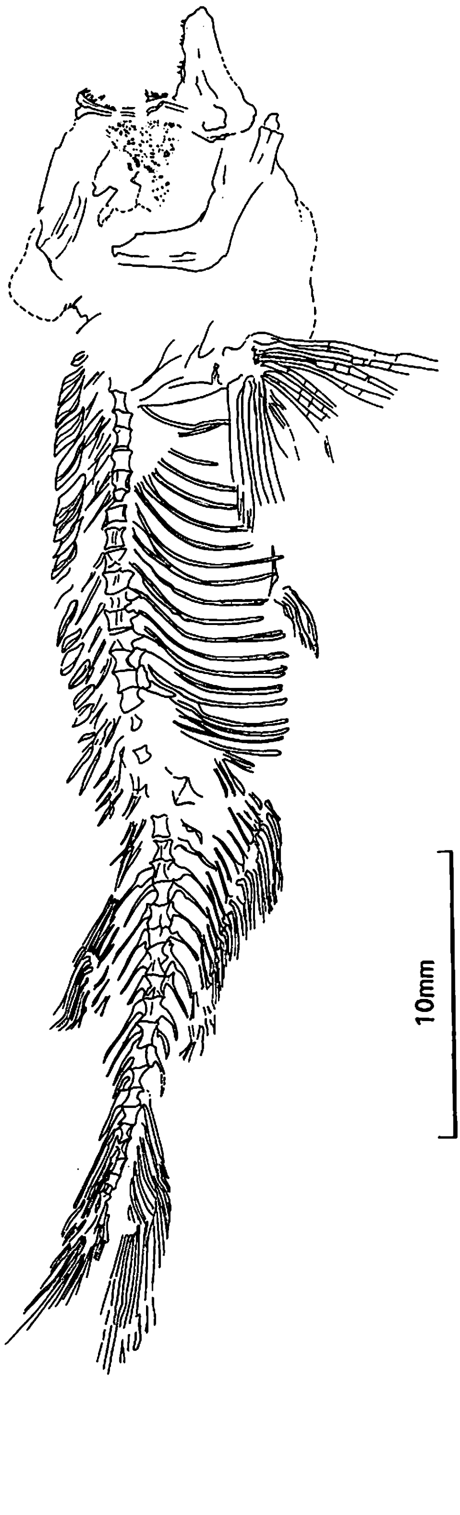

Fig. 60. *Wakinoichthys robustus* gen. et sp. nov., the holotype, KMNH VP 100,188.

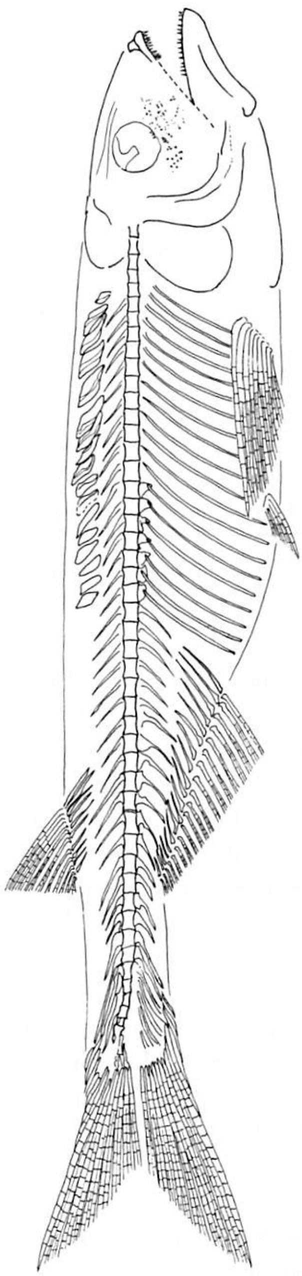

Fig. 61. *Wakinoichthys robustus* gen. et sp. nov., restoration of the skeleton.

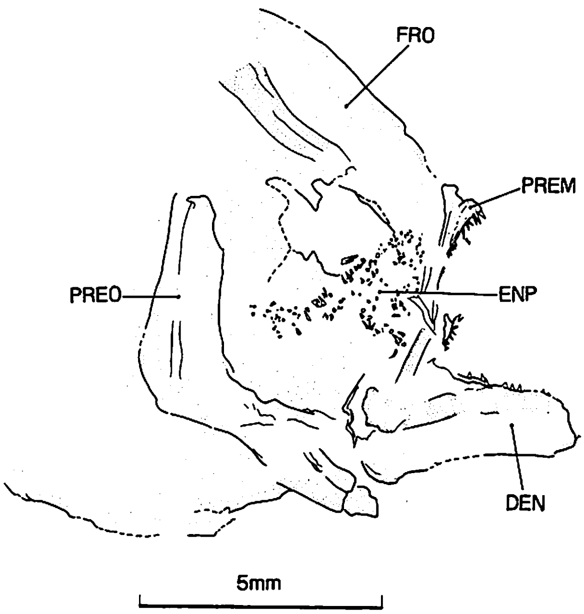

Fig. 62. *Wakinoichthys robustus* gen. et sp. nov., head region of the holotype, KMNH VP 100,188.

rays are visible. Five pelvic fin rays are visible. There are 18 principal caudal fin rays (1,8,8,1). The gape of the mouth is large. The anterior part of the lower jaw is missing. The suture between the dentary and anglo-articular is not visible and the posterior part of the lower jaw is poorly preserved. The premaxilla bears small canine like teeth. The posterior end of the lower jaw is placed below almost center of the orbit. There are villiform teeth on the endopterygoid. The endopterygoid is large (Fig. 62). The total number of vertebrae is 45, with 22 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae was estimated on the basis of the number of ribs. The number of ribs is 21.

There is a series of median supraneurals beginning immediately behind the head and ending above the first caudal vertebra. Each supraneural is wide and leaf-shape with a ridge running from a dorsal end to a ventral end. The first preural centrum bears the narrow parhypural (Fig. 63).

Description of the paratypes.

In KMNH VP 100,189, the body depth is contained 3.5 times in the standard length. The head length is contained 3.2 times in the standard length. The first dorsal fin pterygiophore is inserted between the fifth and the sixth caudal vertebrae. The dorsal fin base is contained 2.4 times in the anal fin base. The number of

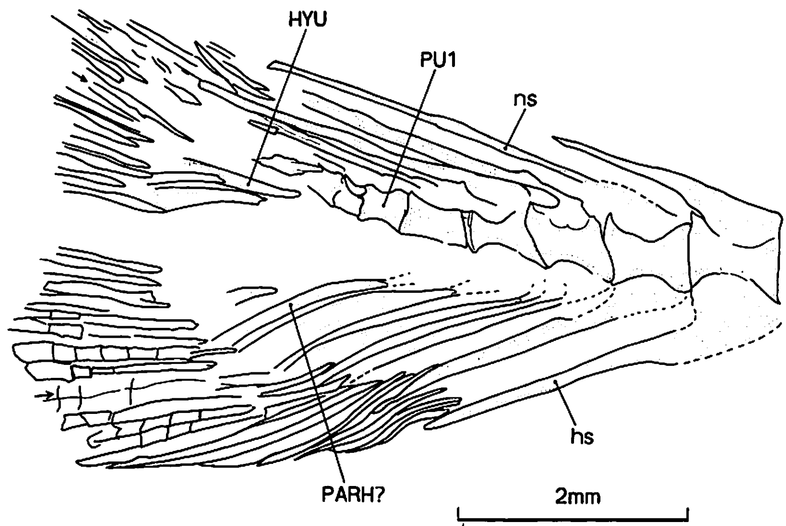

Fig. 63. *Wakinoichthys robustus* gen. et sp. nov., caudal skeleton of the holotype, KMNH VP 100,188.

principal dorsal fin rays is 10. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores. The principal dorsal fin rays are preceded by two small unbranched accessory rays. The principal anal fin rays are preceded by four small unbranched accessory rays. The total number of vertebrae is 47, with 22 caudal vertebrae. The number of ribs is 23.

In KMNH VP 100,190, the first dorsal fin pterygiophore is between the sixth and the seventh caudal vertebra. The number of principal dorsal fin rays is over 10. The number of dorsal fin pterygiophores is over 10. The number of principal anal fin rays is over 10. The number of anal fin pterygiophores is over 10. The principal dorsal fin rays are preceded by two small unbranched accessory rays. The principal anal fin rays are preceded by four small unbranched accessory rays. Villiform teeth are present on the endopterygoid. The number of caudal vertebrae is 26. The number of ribs is 24. The sagitta is large and round.

In KMNH VP 100,191, the first dorsal fin pterygiophore is inserted between the sixth and seventh caudal vertebrae. The dorsal fin base is contained 2.7 times in the anal fin base. There are 11 dorsal fin pterygiophores. There are 22 anal fin pterygiophores. The number of caudal vertebrae is 22.

Remarks. This new species, *Wakinoichthys robustus* is close to *W. aokii* in having almost same meristic characters, the position of median fins, the form of median supraneurals and the long pectoral fin. But it differs from *W. aokii* in the proportion. The body depth of *W. robustus* is deeper than that of *W. aokii*. The depth is contained 3.5 to 3.8 times in the standard length in *W. robustus*, 4.5 to 6.4 times in *W. aokii*

(Tab. 4). The pectoral fin is long in both species, but it does not extend beyond the pelvic insertion in *W. robustus*, the pectoral fin extends beyond the pelvic insertion in *W. aokii*.

Infradivision Clupeomorpha
Order Clupeiformes
Family Clupeidae

Genus ***Diplomystus*** COPE, 1877

Diagnosis. See GRANDE (1982). The characteristics of the species from the Wakino Subgroup do not agree with the diagnosis by GRANDE (1982), but the present author tentatively leaves these species under the genus *Diplomystus* until further comparison with other genera and species in detail.

Type species. *Diplomystus dentatus* COPE, 1877.

Diplomystus primotinus UYENO, 1979
(Figs. 64–67, Pl. 53)

Holotype. KMNH VP 100,001, an almost complete specimen, with its right side exposed, but the upper lobe of caudal fin is missing. The standard length is 63.0 mm.

Additional specimens. KMNH VP 100,192, an almost complete specimen, with its left side exposed, but bones of the head region is slightly moved. The standard length is 42.9 mm. KMNH VP 100,193, an almost complete specimen, with its right side exposed. The standard length is 46.6 mm. KMNH VP 100,194, an almost complete specimen, with its left side exposed. The standard length is 49.4 mm. KMNH VP 100,195, an almost complete specimen, with its right side exposed, but a part of the anal fin is missing. The standard length is 53.7 mm. KMNH VP 100,196, an almost complete specimen, with its left side exposed, but the dorsal margin in front of the dorsal fin is missing. The standard length is 31.7 mm. KMNH VP 100,198, an almost complete specimen, with its left side exposed, but a part of the anal fin is missing. The standard length is 51.4 mm. KMNH VP 100,199, an almost complete specimen, with its left side exposed, but parts of the anal fin and the caudal vertebrae are missing. The standard length is 36.3 mm. KMNH VP 100,200, an almost complete specimen, with its right side exposed, but parts of the anal and dorsal fins are missing. The standard length is 47.3 mm. KMNH VP 100,201, an almost complete specimen, with its left side exposed, but a part of the anal fin is missing. The standard length is 69.6 mm. KMNH VP

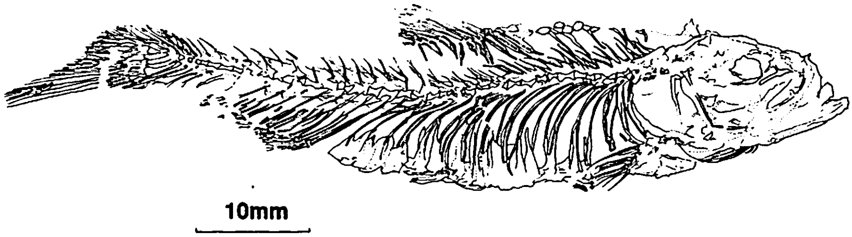

Fig. 64. *Diplomistus primotius* UYENO, 1979, the holotype, KMNH VP 100,001. From UYENO and YABUMOTO, 1980.

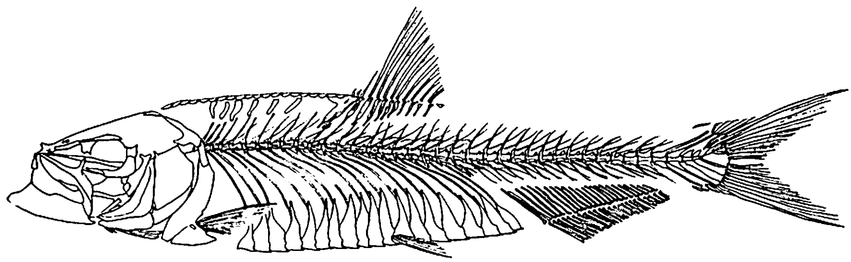

Fig. 65. *Diplomistus primotius* UYENO, 1979, restoration of the skeleton. From UYENO and YABUMOTO, 1980.

100,202, an anterior part of the body, with its left side exposed. The length from the pectoral insertion to the end of the hypural is 43.6 mm.

Locality. Kumagai (KA-0), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Fourth Formation (the uppermost formation, W_4, correlated to the Upper Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

The original description is as follows.

Diagnosis. This new species differs from other members of the genus in having the following characters. The predorsal scutes are oval in shape with rounded anterior and posterior ends, as opposed to pointed or concave ends. The body depth is about one-fourth of the standard length. The head length is about one-third of the standard length.

The number of dorsal pterygiophores is 11 to 12 and anal fin pterygiophores is 24 to 25. The total number of vertebrae is 37 with 20 abdominal and 17 caudal vertebrae. The number of ventral scutes is 18 to 19 in total, with 10 to 11 scutes between the pectoral and pelvic fins, and 7 to 9 scutes between the pelvic and anal fins. The number of predorsal interneural spines is 7.

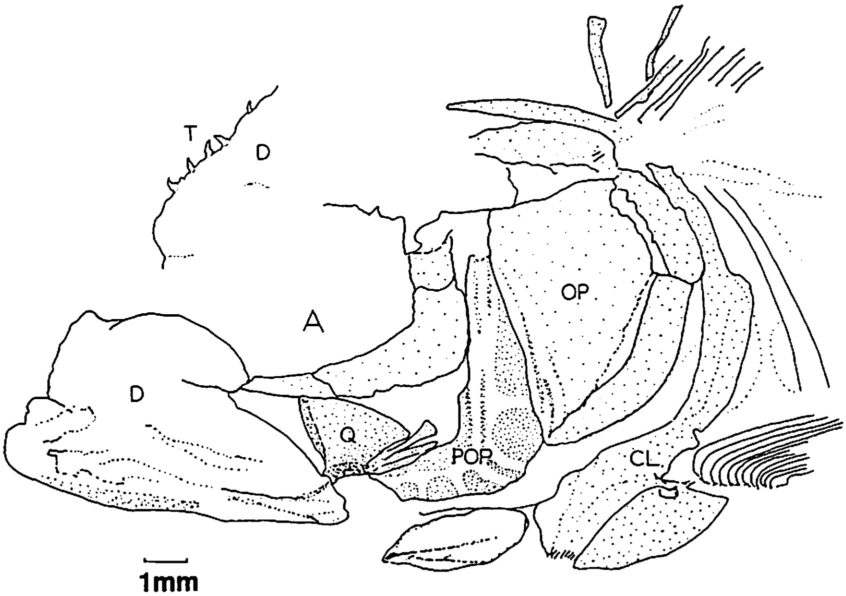

Fig. 66. *Diplomistus primotius* UYENO, 1979, head region of the holotype, KMNH VP 100,001. From UYENO, 1979.

Description of the holotype.

The body is slender and the body depth is contained 4.2 times in the standard length. The head length is contained 3.4 times in the standard length. The dorsal fin is situated at about the middle of the body, and the pelvic fin, below the dorsal fin. The pectoral fin is situated near the ventral edge of the body at the posteroventral corner of the head. The number of dorsal fin pterygiophores is 12. The base of the anal fin is long with 24 pterygiophores. (The number of pterygiophores is usually equal to the number of principal dorsal or anal rays in the closely related Recent species, *Hyperlophus vittatus* CASTELNAU). Seven predorsal scutes are visible. The ventral scutes are well-developed and total 19 in number, with 11 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 37, with 20 abdominal and 17 caudal vertebrae. Seven predorsal interneural spines are present. The neural spines of the first to the 15th vertebrae are divided into two. The intermuscular bones are well-developed, especially in the caudal region. The number of predorsal interneural spine is 7. At least 2 epurals are visible. One parhypural and 6 hypural bones are present.

Description of additional specimens.

In KMNH VP 100,192, the body depth is contained 4.1 times in the standard length. The head length is contained 3.7 times in the standard length. The number of dorsal fin pterygiophores is 10. The number of anal fin pterygiophores is

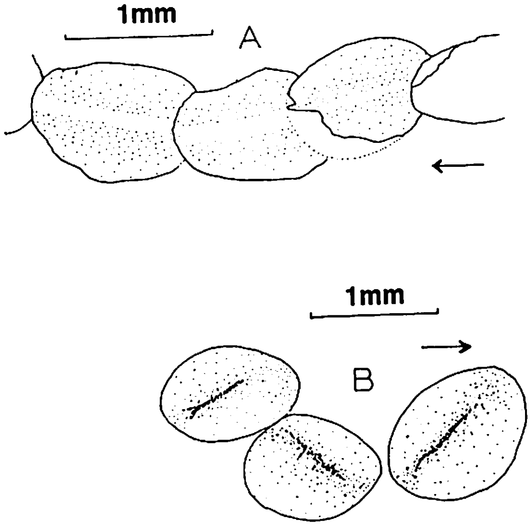

Fig. 67. *Diplomistus primotius* UYENO, 1979. A, predorsal scutes of the holotype, KMNH VP 100,001. B, predorsal scutes of KMNH VP100,006. From UYENO, 1979

24. Seven predorsal scutes are visible. The number of ventral scutes is 17, with 9 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 17 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 3.4 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,193, the body depth is contained 3.8 times in the standard length. The head length is contained 3.7 times in the standard length. The number of dorsal fin rays is 10. The number of dorsal fin pterygiophores is 10. The number of anal fin rays is 25. Five predorsal scutes are visible. The ventral scutes are 18. The total number of vertebrae is 34, with 18 abdominal and 16 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.4 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,194, the body depth is contained 4.4 times in the standard length. The head length is contained 3.8 times in the standard length. The number of dorsal fin rays is 10. The number of anal fin pterygiophores is over 22. Ten predorsal scutes are visible. The ventral scutes are total 17, with 10 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. There are 4 ventral scutes, which do not have vertical elements, under the coracoid. The total number of vertebrae is 34, with 18 abdominal and 16 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the

abdominal vertebral column at the maximum depth of the body is contained 3.0 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,196, the body depth is contained 4.2 times in the standard length. The head length is contained 3.8 times in the standard length. The number of dorsal fin rays is 10. Six predorsal scutes are visible. The ventral scutes are total 20, with 10 scutes between the pectoral and pelvic fins, and 10 scutes between the pelvic and anal fins. The total number of vertebrae is 36, with 19 abdominal and 17 caudal vertebrae. The number of ribs is 17. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.6 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,197, the body depth is contained 5.7 times in the standard length. The head length is contained 3.8 times in the standard length. The number of dorsal fin rays is 11. The number of dorsal fin pterygiophores is 10. The number of anal fin rays is 22. Five predorsal scutes are visible. The ventral scutes are total 17, with 10 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. The total number of vertebrae is 36, with 17 caudal vertebrae. The number of ribs is 17. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 1.9 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,198, the body depth is contained 4.3 times in the standard length. The head length is contained 3.7 times in the standard length. The number of dorsal fin rays is 11. The number of dorsal fin pterygiophores is 11. The number of anal fin pterygiophores is 23. The ventral scutes are total 17, with 9 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.3 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,199, the body depth is contained 4.3 times in the standard length. The head length is contained 3.6 times in the standard length. The number of dorsal fin rays is 11. The number of dorsal fin pterygiophores is 10. The number of anal fin pterygiophores is 23. The ventral scutes are total 16, with 9 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. The total number of vertebrae is 34, with 16 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.7 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,200, the body depth is contained 3.5 times in the standard

length. The head length is contained 3.8 times in the standard length. The number of dorsal fin rays is over 9. Four predorsal scutes are visible. The ventral scutes are total 16, with 9 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 17 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.1 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,201, the body depth is contained 4.3 times in the standard length. The head length is contained 4.3 times in the standard length. The number of dorsal fin rays is 10. The number of dorsal fin pterygiophores is 10. Six predorsal scutes are visible. The ventral scutes are total 17, with 9 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 17 caudal vertebrae. The number of ribs is 16. Seven supraneurals are visible. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.0 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,202, the number of dorsal fin rays is 11. The number of dorsal fin pterygiophores is 11. The number of anal fin pterygiophores is 22. Five predorsal scutes are visible. The ventral scutes are total 18, with 10 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17. Seven supraneurals are visible. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 1.9 times in the depth between the abdominal vertebral column and the ventral margin of the body.

Remarks. *Diplomystus primotinus* is closest to *Diplomystus* sp. in having almost same meristic characters and the proportion, but *D. primotinus* differs from *D.* sp. in the form of the preopercle. The angle between the upper and the lower limbs of the preopercle is an right-angled in *D. primotinus,* an obtuse in *D.* sp. The body depth of *D.* sp. is slightly deeper than that of *D. primotinus. D. primotinus* has the most elongate body in this genus (Tab. 5).

Diplomystus kokuraensis UYENO, 1979.

(Figs. 68–72, Pl. 54)

Holotype. KMNH VP 100,031, an almost complete specimen, with its left side exposed, but a part of the body behind the dorsal fin is missing. The standard length is 35.8 mm.

Table 5. Comparison of characters in the species of the genus *Diplomystus*.

	Diplomystus primotinus	*D. kokuraensis*	*D. altisomus* sp. nov.	*D.* sp.
counts				
D.	11–12	11–12	1.9–2.5	11
D. pterygiophore	11–12	11–12	10–12	10–12
A.	24–25	20–27	23–24	22–25
A. pterygiophore	24–25	20–27	23–24	22–25
Vertebrae	36–37 (19–20+17)	33–36 (18–20+15–16)	34–36 (18–20+16)	34–36 (18–2+16)
Predorsal scutes	—	—	6–10	5–7
Ventral scutes	10–11+7–8=18–19	9–10+8=17–18	10+7–8=17–18	iv+11+7–9 =18–20
Supraneurals	7–8	7	7	6–7
ratio				
SL/BD	4.2	1.9	1.9–2.5	(2.0)3.2–3.7
SL/HL	3.4	3.4	3.6–3.7	3.2–3.9
AB/DB	1.3	1.2	1.8–2.1	1.8
other characters				
Angle of preopercle	right	?	right	obtuse
Ventral margin of abdomen	slightly convex	convex	remarkably convex	slightly convex

A., anal fin rays; AB, anal fin base; BD, body depth; D., dorsal fin rays; DB, dorsal fin base; HL, head length; SL, standard length.

Additional specimens. KMNH VP 100,203, an almost complete specimen, with its right side exposed, but the caudal part of the body is poorly preserved. The standard length is 47.2 mm. KMNH VP 100,204, an almost complete specimen, with its right side exposed, but the part of the anal fin is missing. Bones of head region are moved. The standard length is 53.1 mm. KMNH VP 100,205, an almost complete specimen, with its left side exposed, but the anal fin and dorsal margin of the body in front of the dorsal origin are missing. The standard length is 42.9 mm. KMNH VP 100,206, an almost complete specimen, with its right side exposed, but the parts of the dorsal and anal fins are missing. The standard length is 49.7 mm. KMNH VP 100,207, an almost complete specimen, with its left side exposed, but a part of the anal fin and a part of the head region are missing. The standard length is 48.2 mm. KMNH VP 100,208, an almost complete specimen, with its right side exposed, but posterior parts of the anal and dorsal fins are missing. The standard length is 31.1 mm. KMNH VP 100,209, an almost complete specimen, with its right side exposed, but the dorsal margin of the body in front of dorsal fin is missing. Bones of the abdomen are slightly moved. The standard length is 47.2 mm. KMNH VP 100,210, an anterior part of the body with its right side exposed. The length from the snout to the anal origin is 49.7 mm.

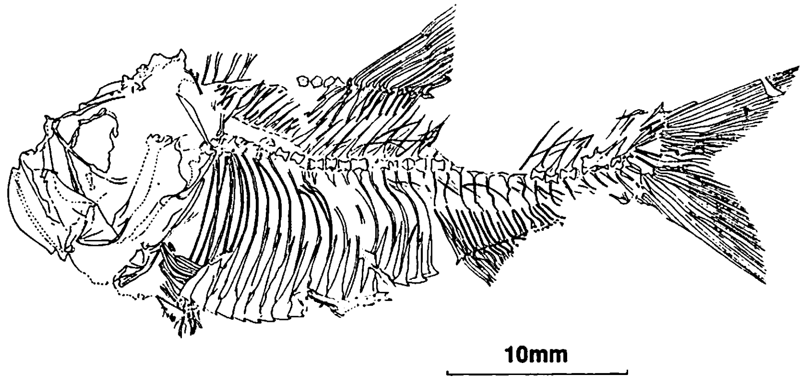

Fig. 68. *Diplomistus kokuraensis* UYENO, 1979, the holotype, KMNH VP 100,031. From UYENO and YABUMOTO, 1980.

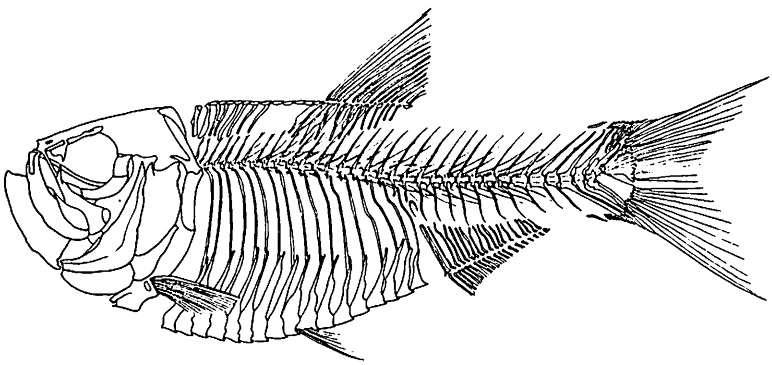

Fig. 69. *Diplomistus kokuraensis* UYENO, 1979, restoration of the skeleton. From UYENO and YABUMOTO, 1980.

Locality. Kumagai (KA-0), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Fourth Formation (the uppermost formation, W_4, correlated to the Upper Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

The original description is as follows.

Diagnosis. This species differs from other members of the genus in having the following characters. The predorsal scutes are round in shape and their lengths are almost equal to or shorter than their widths. The anterior and posterior ends of the scutes are round, as opposed to pointed or concave. The body depth is about half of the standard length. The head length is about one-third of the standard length.

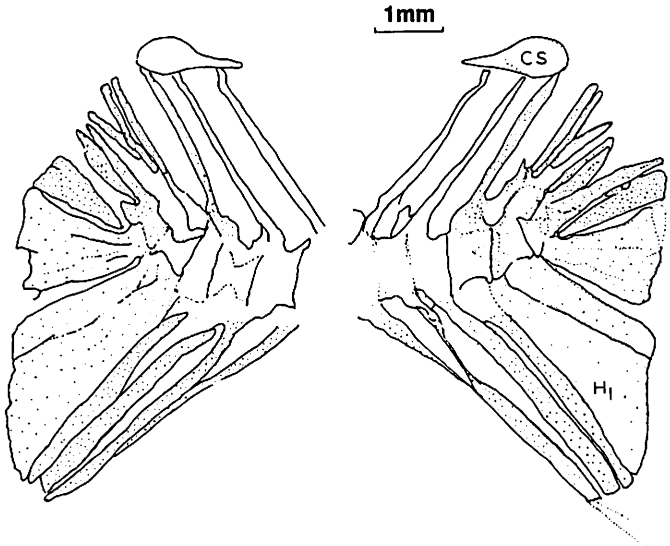

Fig. 70. *Diplomistus kokuraensis* UYENO, 1979, caudal skeleton of KMNH VP 100,035. From UYENO, 1979.

The number of dorsal fin pterygiophores is 11 to 12. The number of anal fin pterygiophores is 20 to 22. The total number of vertebrae is 36, with 20 abdominal vertebrae and 16 caudal vertebrae. The ventral scutes are well-developed, and their number is 17 to 18, with 9 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The number of predorsal interneural spines is 7. The intermuscular bones are well developed.

Description of the holotype. The body is thick and the body depth is contained 1.9 times in the standard length. The head length is contained 3.4 times in the standard length. The dorsal fin is situated at about the middle of the body, and the pelvic fin, below the dorsal fin. The pectoral fin is situated near the ventral edge of the body at the posteroventral corner of the head. The number of dorsal fin pterygiophores is 12, and the number of anal fin pterygiophores is 23. Four predorsal scutes are visible. The ventral scutes are well-developed, totaling 17 in number, with 9 scute between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 32, with 18 abdominal and 14 caudal vertebrae. Seven predorsal interneural spines are present. The neural spines of the first to the 7th vertebrae are divided into two. The intermuscular bones are well-developed. At least 2 epurals are visible. A parhypural and 6? hypurals are present.

Description of additional specimens.

In KMNH VP 100,203, the body depth is contained 2.7 times in the standard

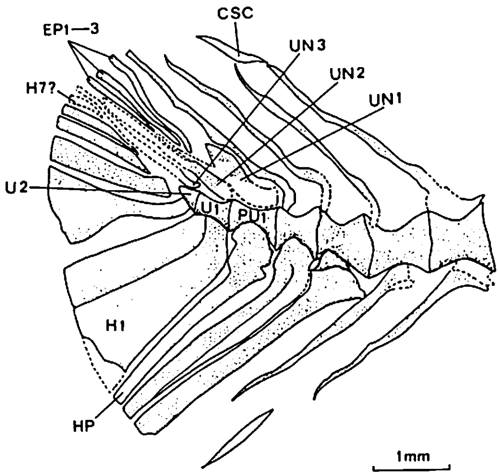

Fig. 71. *Diplomistus kokuraensis* UYENO, 1979, caudal skeleton of the paratype, KMNH VP 100,035. From UYENO and YABUMOTO, 1980.

length. The head length is contained 3.8 times in the standard length. The number of dorsal fin rays is 10. The number of dorsal fin pterygiophores is 10. The number of anal fin rays is 17. The number of anal fin pterygiophores is 17. Four predorsal scutes are visible. The number of ventral scutes is 17, with 11 scutes between the pectoral and pelvic fins, and 6 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 17 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.2 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,204, the body depth is contained 2.6 times in the standard length. The head length is contained 3.7 times in the standard length. The number of dorsal fin rays is 10. The number of dorsal fin pterygiophores is 10. Five predorsal scutes are visible. The number of ventral scutes is 17, with 9 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 1.9 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,205, the body depth is contained 3.1 times in the standard length. The head length is contained 3.6 times in the standard length. The number of dorsal fin rays is 12. The number of ventral scutes is 16, with 10 scutes between the pectoral and pelvic fins, and 6 scutes between the pelvic and anal fins. The total number of vertebrae is 34, with 16 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal

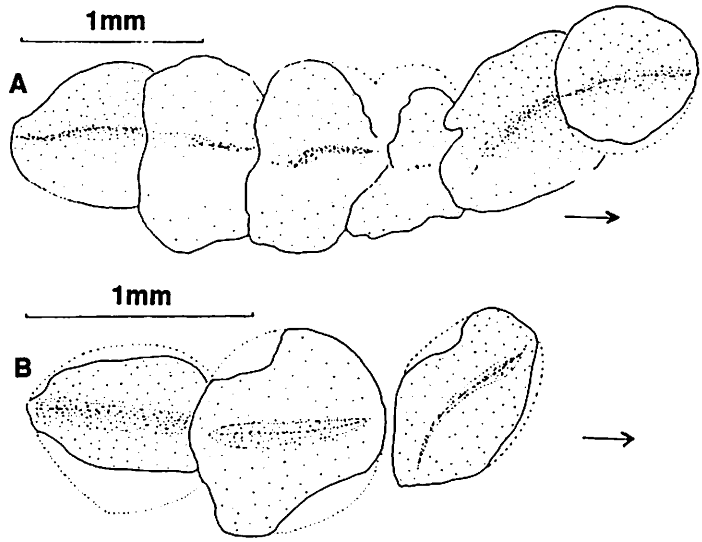

Fig. 72. *Diplomistus kokuraensis* UYENO, 1979. A, predorsal scutes of the paratype, KMNH VP 100,033. B, predorsal scutes of the holotype, KMNH VP100,031. From UYENO, 1979.

vertebral column at the maximum depth of the body is contained 2.6 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,206, the body depth is contained 2.7 times in the standard length. The head length is contained 3.7 times in the standard length. The number of dorsal fin rays is over 6. The number of dorsal fin pterygiophores is over 8. The number of anal fin pterygiophores is 23. The number of scutes between the pelvic and anal fins is 8. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.5 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,207, the body depth is contained 2.7 times in the standard length. The head length is contained 3.7 times in the standard length. The number of dorsal fin rays is 10. The number of dorsal fin pterygiophores is 10. Six predorsal scutes are visible. The number of ventral scutes is 17, with 8 scutes between the pectoral and pelvic fins, and 9 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 19 abdominal and 16 caudal vertebrae. The number of ribs is 17. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.8 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,208, the body depth is contained 2.5 times in the standard length. The head length is contained 3.7 times in the standard length. The number of anal fin pterygiophores is 25. Three predorsal scutes are visible. The number of ventral scutes is 20, with 12 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 34, with 18 abdominal and 16 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 1.9 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,209, the body depth is contained 2.9 times in the standard length. The head length is contained 3.7 times in the standard length. The number of dorsal fin rays is 10. The number of anal fin rays is 23. The number of anal fin pterygiophores is 23. Four predorsal scutes are visible. The number of scutes between the pelvic and anal fins is 6. The total number of vertebrae is 35, with 17 caudal vertebrae. The number of ribs is 16. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.3 times in the depth between the abdominal vertebral column and the ventral margin of the body.

In KMNH VP 100,210, the number of dorsal fin rays is 10. The number of dorsal fin pterygiophores is 11. Four predorsal scutes are visible. The number of ventral scutes is 17, with 9 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The number of ribs is 17. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 2.2 times in the depth between the abdominal vertebral column and the ventral margin of the body.

Remarks. This species is closest to *Diplomystus altisomus* in meristic characters and almost same proportion. But *D. kokuraensis* differs from *D. altisomus* in the out line of the abdomen. The restored outline of the abdomen of *D. altisomus* is more convex than that of *D. kokuraensis*. The body depth of *D. altisomus* deeper than the depth of *D. kokuraensis*. The predorsal scutes are round in shape and their lengths are almost equal to or shorter than their widths in *D. kokuraensis*, their lengths are almost equal to their widths in *D. altisomus*.

Diplomystus altisomus sp. nov.

(Figs. 73–77, Pl. 55)

Diagnosis. It differs from other species of the genus in having the combination of following characters. The predorsal scutes are round in shape and their lengths are almost equal to their widths. The anterior and posterior ends of the scutes are round. The body is remarkably deep and is contained 1.9 to 2.5 times in the

standard length. The restored outline of the abdomen is remarkably convex. The head length is contained 3.6 to 3.7 times in the standard length. The angle between the upper and lower limbs of the preopercle is right-angled. The depth between the dorsal margin of the body and the abdominal vertebral column at the maximum depth of the body is contained 3.3 times in the depth from the abdominal vertebral column and the ventral margin of the body. The number of dorsal fin pterygiophores is 10 to 12. The number of anal fin pterygiophores is 23 to 24. The total number of vertebrae is 34 to 36, with 16 caudal vertebrae. The number of ventral scutes is 17 to 18 in total, with 10 scutes between the pectoral and pelvic fins, and 7 to 8 scutes between the pelvic and anal fins. The number of supraneurals is 7.

Holotype. KMNH VP 100,217, an almost complete specimen, with its left side exposed, but the posterior part of the caudal fin is missing. The standard length is 46.6 mm.

Paratypes. KMNH VP 100,218, an almost complete specimen, with its left side exposed. The standard length is 36.8 mm. KMNH VP 100,219, an almost complete specimen, with its left side exposed. The length from the snout to the fifth caudal vertebra is 32.2 mm. KMNH VP 100,220, an almost complete specimen, with its left side exposed, but the dorsal fin, a part of the abdomen and the posterior part of the caudal fin are missing. The standard length is 47.1 mm. KMNH VP 100,221, an almost complete specimen, with its left side exposed, but the anterior part of the mandible and the posterior part of the anal fin are missing. The standard length is 29.3 mm.

Locality. Kumagai (KD-34), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Fourth Formation (the uppermost formation, W_4, correlated of the Upper Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species name, *altisomus,* means deep body, which refers to the fact that this species has the deepest body among the species of the genus from the Wakino Subgroup.

Description of the holotype.

The body is deep and the body depth is contained 2.3 times in the standard length. The head length is contained 3.7 times in the standard length. The snout is round. The outline of the head dorsal margin is almost straight, but the restored outline is slightly convex. The outline from the occipital region to the dorsal origin

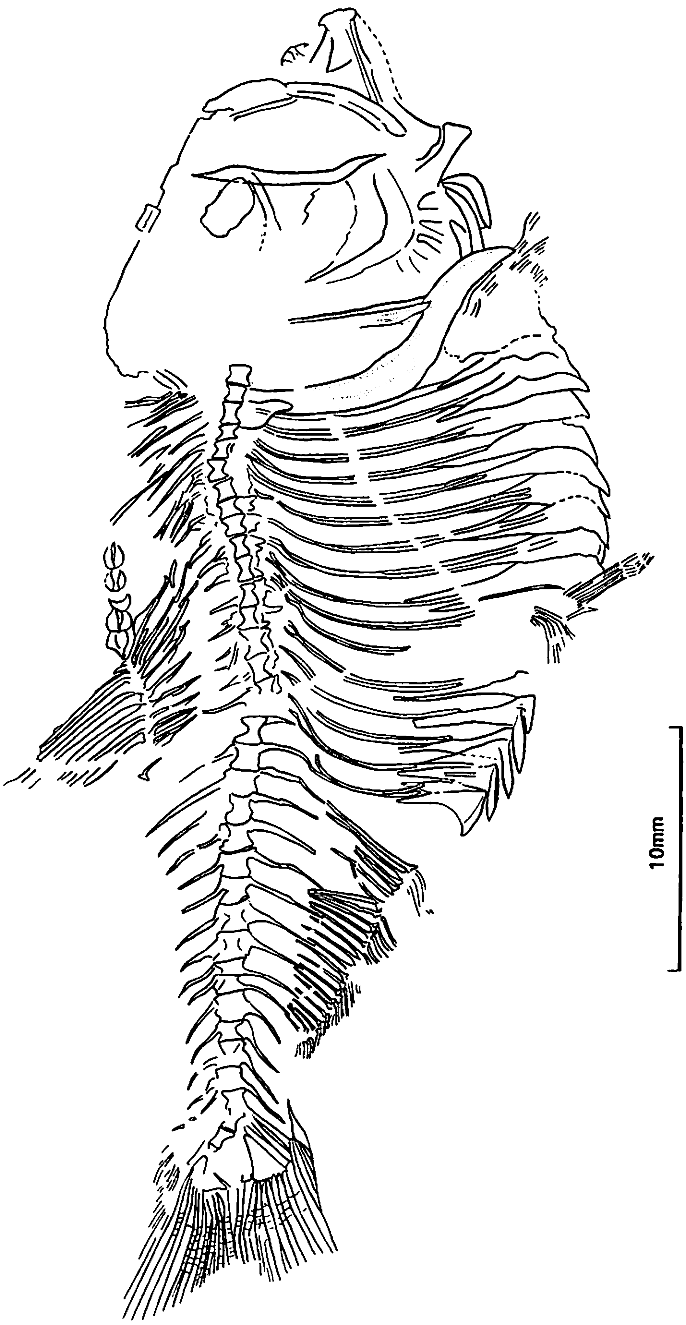

Fig. 73. *Diplomystus altisomus* sp. nov., the holotype, KMNH VP 100,217.

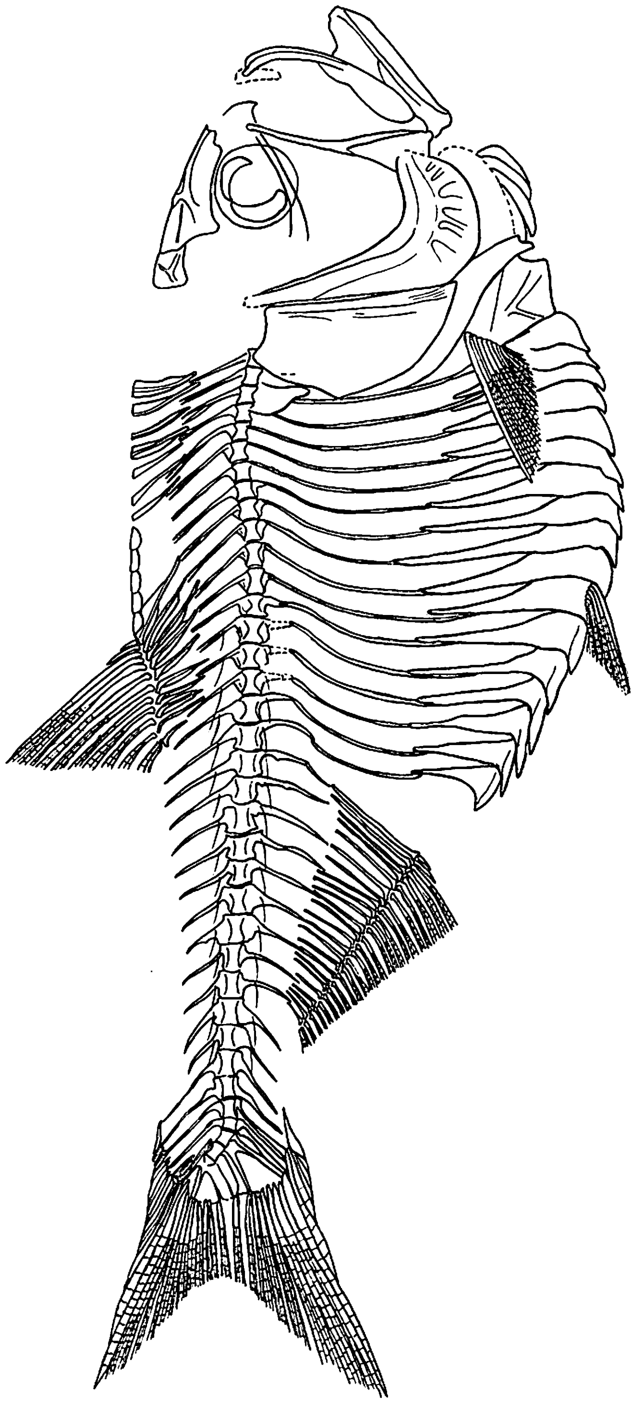

Fig. 74. *Diplomystus altisomus* sp. nov., restoration of the skeleton.

is slightly convex. The restored outline of the abdomen is remarkably convex (Figs. 73 and 74). The dorsal fin is situated at about the middle of the body. The anal origin is well behind the posterior end of the dorsal fin base. The first dorsal fin pterygiophore is above the 9th abdominal vertebra. The dorsal fin base is short and is contained 2.1 times in the anal fin base. The pectoral fin is short and does not reach the pelvic insertion (Figs. 73 and 74). The number of principal dorsal fin rays is 10. There are 10 dorsal fin pterygiophores. The number of principal anal fin rays is 24. There are 24 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by two small unbranched accessory rays respectively. Six pelvic fin rays are visible. There are 18 principal caudal fin rays (1,8,8,1). The pelvic fin is situated at about the middle of the body and the insertion is situated slightly before under the dorsal origin. The gape of the mouth is small. The mandible is short and deep. The dentary bears small teeth on its anterior part of the oral margin. The suture between the dentary and anglo-articular is not visible and the posterior part of the mandible is poorly preserved. There are no teeth on the premaxilla and maxilla. The posterior end of the lower jaw is placed below almost center of the orbit. The parasphenoid teeth are absent. The maxilla is long and wide. The maxilla is slightly curved. The maxilla has a ridge from the dorsal end to the

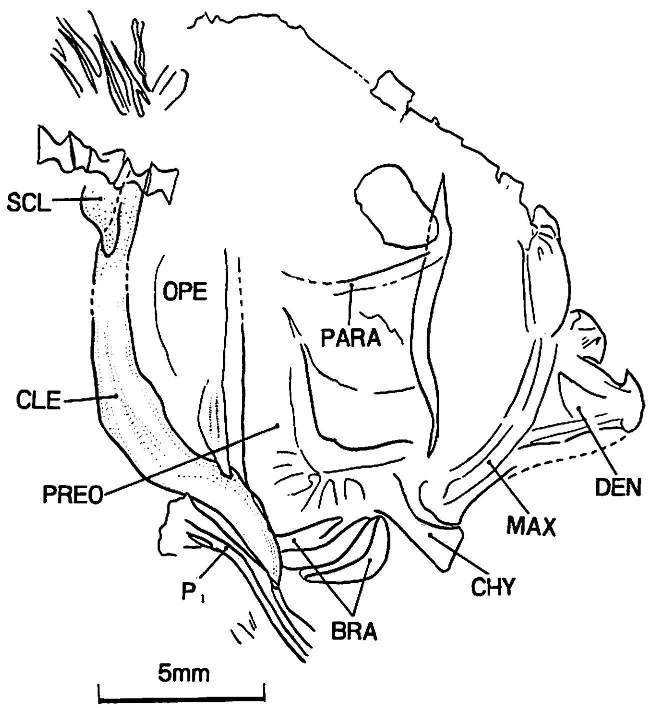

Fig. 75. *Diplomystus altisomus* sp. nov., head region of the holotype, KMNH VP 100,217.

ventral end and has wings both sides of the ridge. The preopercle is L-shape. The sensory canal runs along the anterior margin of the upper limb and the dorsal margin of the lower limb. Five branches of the canal are visible from the corner to the anterior end of the lower limb. Four branchiostegal rays are visible. The opercle is visible (Fig. 75). The predorsal scutes are round in shape and their lengths are almost equal to their widths. The anterior and posterior ends of the scutes are round. Five predorsal scutes are visible. The ventral scutes are well developed and total 17 in number, with 10 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. The total number of vertebrae is 34, with 16 caudal vertebrae (Fig. 73). The anterior end of the vertebral column is not visible. The number of abdominal vertebrae was estimated on the basis of the number of ribs. The number of ribs is 16. Five median supraneurals are visible. The first preural centrum bears the cylindrical parhypural. The neural arch and spine of the first preural centrum are complete. The first hypural is the largest. The second hypural is about one fourth of the first one in width. There are two ural centra. The second ural centrum bears at least three hypurals. Two uroneurals are visible. The number of epurals is 3. There is a caudal scute before the procurrent caudal fin rays of the lower lobe (Fig. 76).

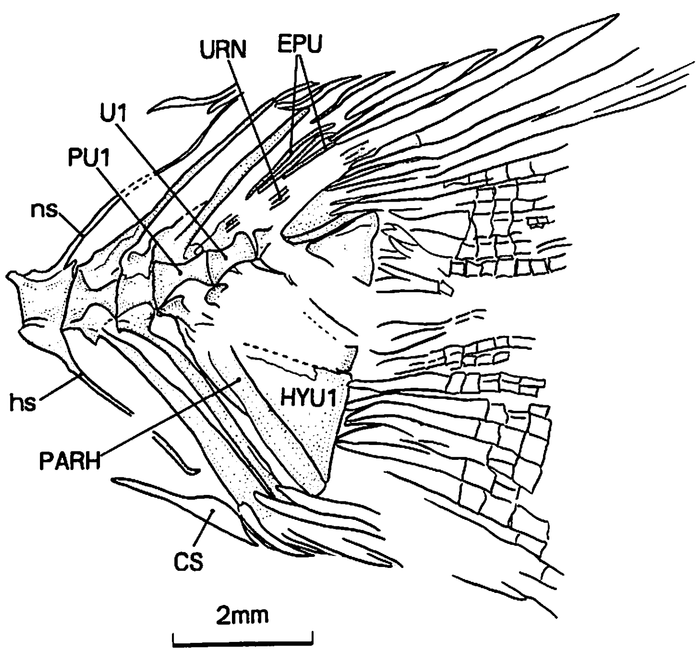

Fig. 76. *Diplomystus altisomus* sp. nov., caudal skeleton of the holotype, KMNH VP 100,217.

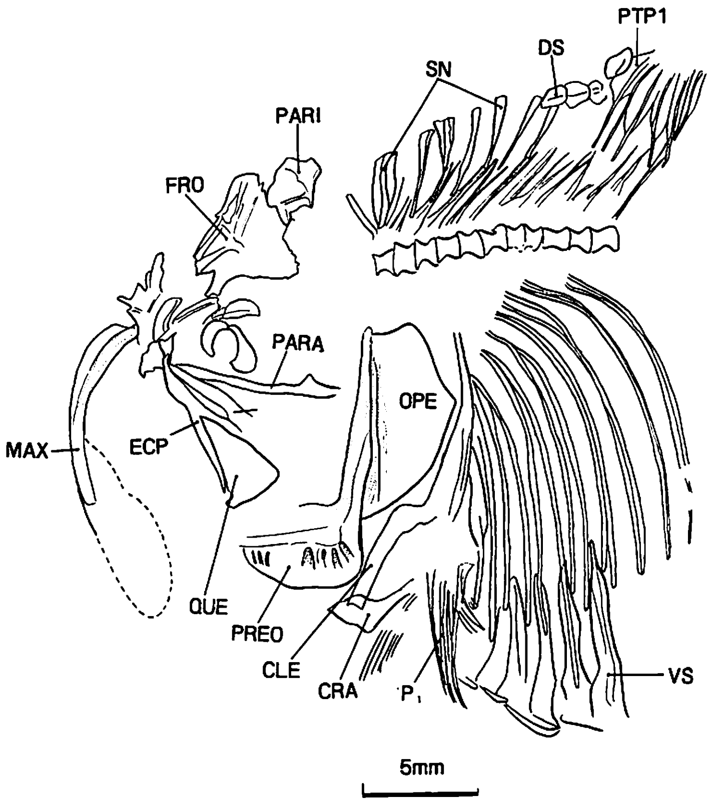

Fig. 77. *Diplomystus altisomus* sp. nov., anterior part of the body, KMNH VP 100,219.

Description of the paratypes.

In KMNH VP 100,218, the body depth is contained 2.5 times in the standard length. The head length is contained 3.7 times in the standard length. The dorsal fin base is short and is contained 1.8 times in the anal fin base. The number of principal dorsal fin rays is 10. The number of principal anal fin rays is 23. There are 23 anal fin pterygiophores. Ten predorsal scutes are visible. The ventral scutes are well developed and total 17 in number, with 10 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17.

In KMNH VP 100,219, the number of principal dorsal fin rays is 12. There are 12 dorsal fin pterygiophores. Four predorsal scutes are visible (Fig. 77). The ventral scutes are well developed and total 20 in number, with 10 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 20, with 16 caudal vertebrae. The number of ribs is 18. Seven median supraneurals are present.

In KMNH VP 100,220, the body depth is contained 1.9 times in the standard

length. The head length is contained 3.6 times in the standard length. The number of principal anal fin rays is 24. There are 24 anal fin pterygiophores. The total number of vertebrae is 34, with 16 caudal vertebrae. The number of ribs is 16.

In KMNH VP 100,221, the body depth is contained 2.0 times in the standard length. The head length is contained 3.7 times in the standard length. There are 11 dorsal fin pterygiophores. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17.

Remarks. This new species, *Diplomystus altisomus* is closest to *Diplomystus kokuraensis* UYENO, 1979 in having the almost same proportion, but *D. altisomus* differs from *D. kokuraensis* in the out line of the abdomen. The restored outline of the abdomen of *D. altisomus* is more convex than that of *D. kokuraensis*. The body depth of *D. altisomus* is deeper than the depth of *D. kokuraensis*. This new species has the deepest body in the species of the genus from the Wakino Subgroup (Tab. 5).

Diplomystus sp.

(Figs. 78–82, Pl. 56)

Specimens. KMNH VP 100,211, an almost complete specimen, with its left side exposed. The standard length is 49.1 mm. KMNH VP 100,212, an almost complete specimen, with its right side exposed, but the anal fin is missing with the exception of the most anterior part. The standard length is 52.0 mm. KMNH VP 100,213, an almost complete specimen with its right side exposed, but a part of dorsal fin, the posterior part of the anal fin and the posterior part of the caudal fin are missing. The standard length is 35.7 mm. KMNH VP 100,214, an almost complete specimen with its left side exposed. The standard length is 31.2 mm. KMNH VP 100,215, an almost complete specimen with its left side exposed, but the posterior part of the anal fin is missing. The standard length is 31.2 mm. KMNH VP 100,216, an almost complete specimen with its left side exposed, but the anterior part of the mandible and the posterior part of the anal fin are missing. The standard length is 29.3 mm. KMNH VP 100, 234, an almost complete specimen with its left side exposed. The standard length is 52.1 mm.

Locality. Kumagai (KD-34), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Fourth Formation (the uppermost formation, W_4, correlated to the Upper Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Description.

In KMNH VP 100,211, the body is slender and the body depth is contained 3.5 times in the standard length. The head length is contained 3.2 times in the standard length. The snout is round. The outline of the head dorsal margin is slightly convex. The outline from the occipital region to the dorsal origin is almost straight. The restored outline of the abdomen is slightly convex (Figs. 78 and 79). The dorsal fin is situated at about the middle of the body. The anal origin is behind the end of the dorsal fin base. The first dorsal fin pterygiophore is inserted between the 9th and 10th abdominal vertebrae. The dorsal fin base is short and is contained 1.8 times in the anal fin base. The pectoral fin is short and does not reach the pelvic insertion. The caudal fin is forked. The number of principal dorsal fin rays is 11. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 22. There are 22 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by one small unbranched accessory ray respectively. Thirteen pectoral fin rays are visible. There are 18 principal caudal fin rays (1,8,8,1). The gape of the mouth is small. The mandible is short and deep. The dentary bears small teeth on the anterior end of the oral margin. The suture between the dentary and the anglo-articular is visible and the posterior part of the lower jaw is poorly preserved. The parasphenoid teeth are absent. The frontal is wide and carries a superficial sensory canal. The maxilla is wide and slightly curved. The maxilla has a ridge from the dorsal end to near the ventral end and has wide wings both sides of the ridge. The angle between the upper and lower limbs of the preopercle is an obtuse. The sensory canal runs along the anterior margin of the upper limb. The lower limb of the preopercle is poorly preserved. Parts of the opercle and preopercle are visible (Fig. 80). The predorsal scutes are oval in shape. The anterior end of each dorsal scute is round and the posterior end is slightly pointed (Fig. 81). The ventral scutes are well developed and total 22 in number, with 4 scutes below the pectoral fin, 11 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. Each scute below the pectoral fin does not have vertical elements (Fig. 78). The total number of vertebrae is 36, with 16 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae was estimated on the basis of the ribs. The number of ribs is 18. Six median supraneurals are present. The first supraneural is wide and leaf-shape with a ridge running from the dorsal end to the ventral end. The first preural centrum bears the cylindrical parhypural with narrow wings on its basal part. The neural arch and spine of the first preural centrum are not visible. There are 6 hypurals. The first hypural is the largest. The second hypural is about half of the first one in width. The second hypural is fused with the first ural vertebra. There is a space between the second and the third hypurals. The third to sixth hypurals are slender and cylindrical (Fig. 82).

In KMNH VP 100,212, the body depth is contained 3.7 times in the standard

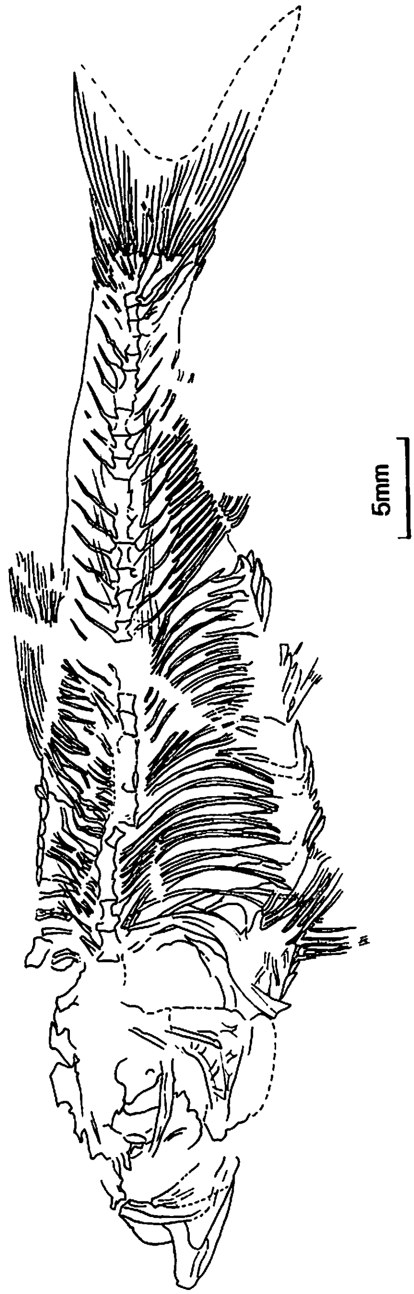

Fig. 78. *Diplomystus* sp., KMNH VP 100,211.

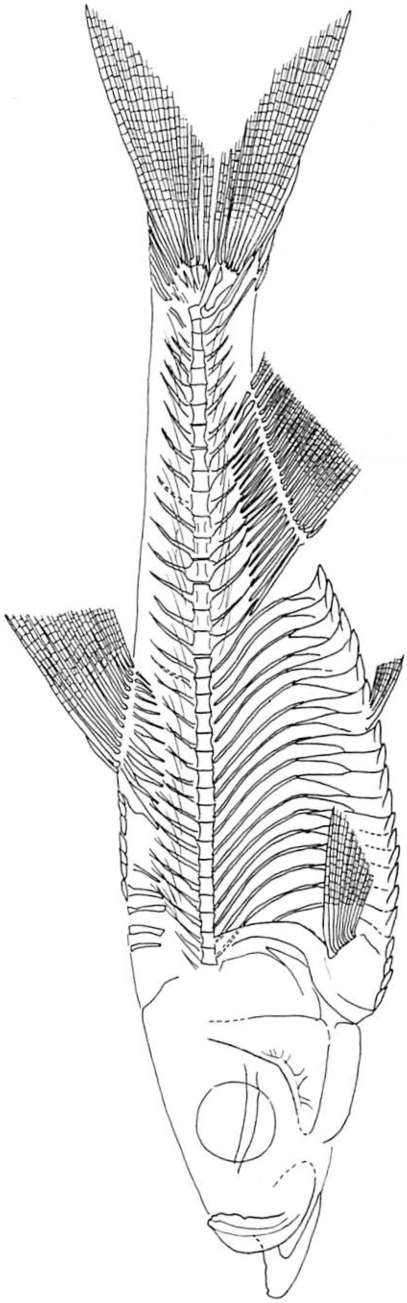

Fig. 79. *Diplomystus* sp., restoration of the skeleton.

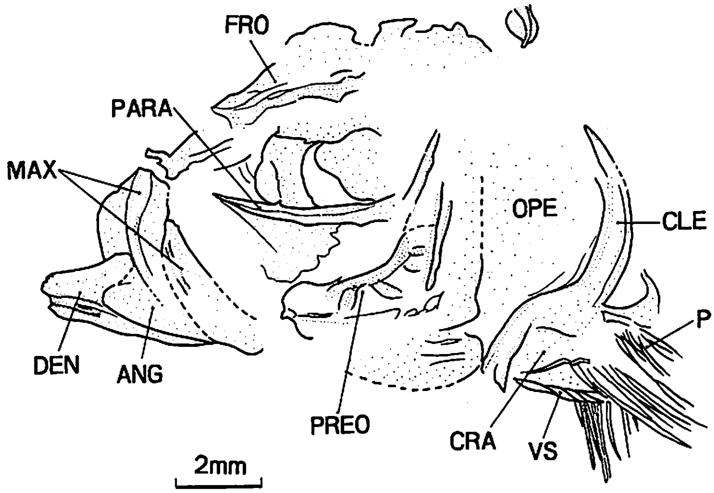

Fig. 80. *Diplomystus* sp., head region of KMNH VP 100,211.

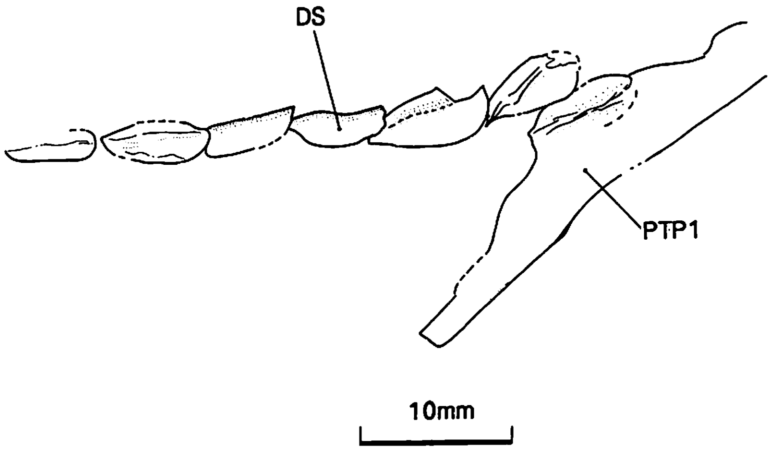

Fig. 81. *Diplomystus* sp., predorsal scutes of KMNH VP 100,211.

length. The head length is contained 3.9 times in the standard length. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. Seven predorsal scutes are visible. The number of ventral scutes is 20, with 11 scutes between the pectoral and pelvic fins, and 9 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17.

In KMNH VP 100,213, the body depth is contained 3.2 times in the standard length. The head length is contained 3.8 times in the standard length. There are 10 dorsal fin pterygiophores. The number of principal anal fin rays is 22. There

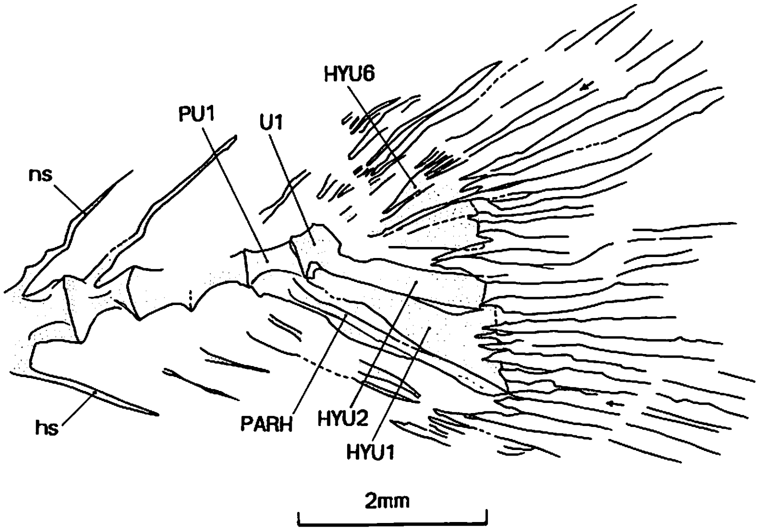

Fig. 82. *Diplomystus* sp., caudal skeleton of KMNH VP 100,211.

are 23 anal fin pterygiophores. The number of ventral scutes is 19, with 4 scutes below the pectoral fin, 11 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17. Seven median supraneurals are present. The first supraneural is wide and leaf-shape with a ridge running from the dorsal end to the ventral end.

In KMNH VP 100,214, the body depth is contained 3.5 times in the standard length. The head length is contained 3.7 times in the standard length. The dorsal fin base is contained 1.8 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 25. There are 25 anal fin pterygiophores. Five dorsal scutes are visible. The number of ventral scutes is 18, with 10 scutes between the pectoral and pelvic fins, and 8 scutes between the pelvic and anal fins. The total number of vertebrae is 34, with 16 caudal vertebrae. The number of ribs is 16. Seven median supraneurals are present.

In KMNH VP 100,215, the body depth is contained 3.5 times in the standard length. The head length is contained 3.9 times in the standard length. The number of ventral scutes is 18, with 11 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. The total number of vertebrae is 34, with 16 caudal vertebrae. The number of ribs is 16. Six median supraneurals are present. The first preural centrum bears the plate like parhypural. The first hypural is the largest. The second hypural is about half of the first one in width. The second hypural is fused with the first ural vertebra.

In KMNH VP 100,216, the body depth is contained 2.0 times in the standard length. The head length is contained 3.7 times in the standard length. There are 11 dorsal fin pterygiophores. The number of ventral scutes is 20, with 14 scutes between the pectoral and pelvic fins, and 6 scutes between the pelvic and anal fins. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17. Six median supraneurals are present.

In KMNH VP 100,234, the body depth is contained 3.6 times in the standard length. The head length is contained 3.4 times in the standard length. There are 12 dorsal fin pterygiophores. There are 28 anal fin pterygiophores. The number of ventral scutes is 17, with 10 scutes between the pectoral and pelvic fins, and 7 scutes between the pelvic and anal fins. The number of dorsal scutes is 11. The total number of vertebrae is 35, with 16 caudal vertebrae. The number of ribs is 17.

Remarks. This species, *Diplomystus* sp., is middle between *D. primotinus* and *D. kokuraensis* in the body depth (Tab. 5). It is closest to *D. primotinus* in having the almost same proportion, but *D.* sp. slightly differs from *D. primotinus* in the form of the preopercle and the body depth. The angle between the upper and lower limbs of the preopercle is an obtuse in *D.* sp., an right-angled in *D. primotinus.* The body depth of *D.* sp. is slightly deeper than that of *D. primotinus.* But these differences are considered to be small to recognize it as a new species in the present study.

Order and Family *incertae sedis*

Genus ***Paraleptolepis*** **gen. nov.**

Diagnosis. The first preural centrum has a rudimentary neural arch. Three epurals are present just behind the neural arch of the first preural centrum. Three uroneurals are present. The first uroneural extends forward beyond the first preural centrum and reaches the anterior end of the second preural centrum. The number of branched caudal fin rays is 17. Teeth are absent on the parasphenoid, endopterygoid and maxilla. The supramaxilla is present. Small canine like teeth are present on the premaxilla and dentary. The frontal is short. Median fins are posterior. The origin of the dorsal fin is just before the anal origin. The dorsal fin base is shorter than the anal fin base. The number of dorsal fin rays is 11 to 12. The number of anal fin rays is 17 to 19. The number of vertebrae is 40 to 42, with 19 to 20 caudal vertebrae.

Type species. *Paraleptolepis kikuchii* sp. nov.

Etymology. The generic name, *Paraleptolepis* consists of *para,* a Greek word meaning beside or near, and *leptolepis,* a generic name of the "Leptolepiformes".

Remarks. The characteristic of the caudal skeleton of this new genus, *Paraleptolepis* are follows. Anterior two uroneurals extend forward beyond the first ural centrum. The neural arch and spine of the first preural centrum are not complete and the rudimentary neural arch is present on the first preural centrum. Three epurals are just behind the neural arch of the first preural centrum.

These characters indicates the relationship with the leptolepid genera, *Leptolepis* and *Leptolepides*, and the elopiform genera, *Anaethalion* and *Pachythrissops*. But *Paraleptolepis* differs from *Anaethalion* in the characters of the skull. The gape of the mouth is large and the parasphenoid and maxillary teeth are present in *Anaethalion* (Fig. 83). *Paraleptolepis* differs from *Pachythrissops* in the following characters. Two rudimentary neural arches are present on the first ural centrum in *Pachythrissops* (Fig. 84). Maxillary teeth are present in *Pachythrissops* (Fig. 85). *Paraleptolepis* is similar to *Leptolepis* and *Leptolepides* in the caudal skeleton, but it differs from these genera in the following characters. The second uroneural does not reach the preural centrum, one rudimentary neural arch is present on the first ural centrum, and the maxilla is large and bears small teeth on its oral margin in *Leptolepis* and *Leptolepides*. *Leptolepis* and *Leptolepides* were once assigned to the family Leptolepidae of the order Leptolepiformes, but the group referred to as leptolepids is not considered to be a valid taxonomic unit (PATTERSON and ROSEN, 1977).

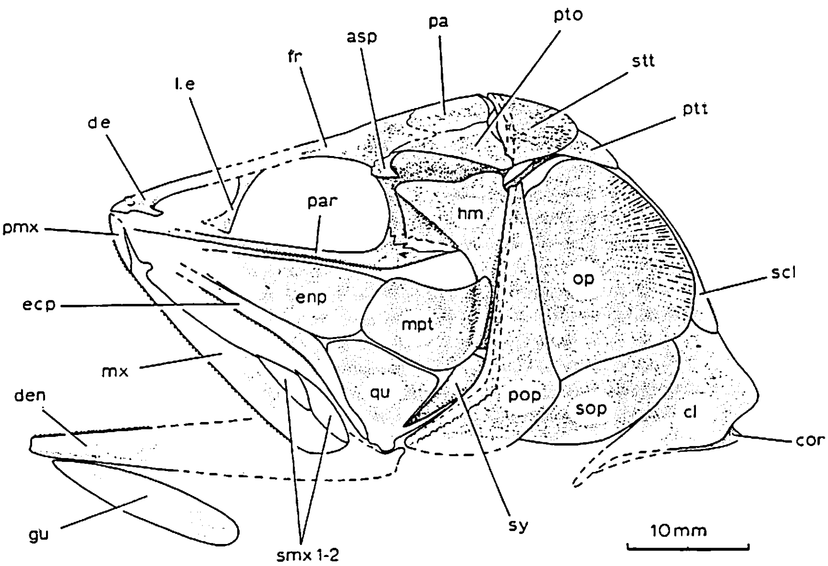

Fig. 83. *Anaethalion vidali* (SAUVAGE, 1903). Cranium and pectoral girdle in left lateral view. From FOREY, 1973.

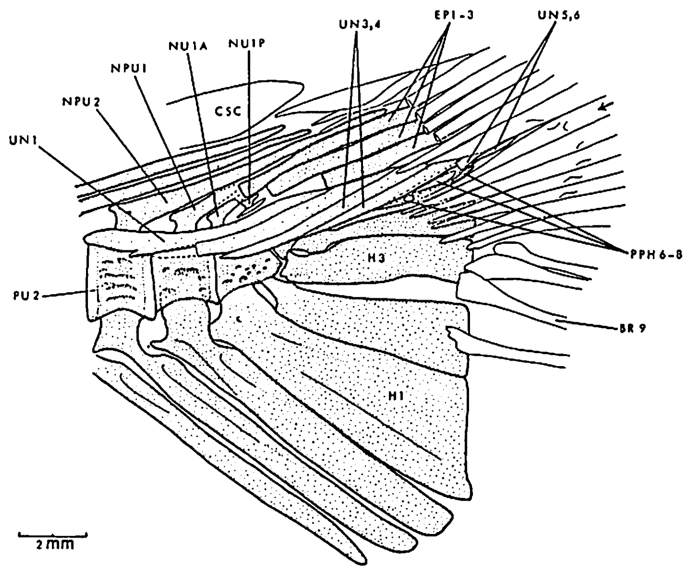

Fig. 84. *Pachythrissops laevis* WOODWARD, 1919, caudal skeleton. From PATTERSON and ROSEN, 1977.

***Paraleptolepis kikuchii* sp. nov.**

(Figs. 86–89, Pl. 57)

Diagnosis. It differs from other species of the genus in having the combination of following characters. The body depth is contained 3.2 to 3.7 times in the standard length. The head length is contained 3.5 to 4.3 times in the standard length. The first dorsal fin pterygiophore is inserted between the neural spines of the first and second caudal vertebrae or above the neural spine of the first caudal vertebra. The pelvic fin is short and does not reach the pelvic insertion. The anterior three anal pterygiophores are inserted between the haemal spines of the first and the second caudal vertebrae. The number of vertebrae is 40 to 42, with 19 to 20 caudal vertebrae. The number of ribs is 18 to 20.

Holotype. KMNH VP 100,222, an almost complete specimen, with its right side exposed. The standard length is 55.5 mm.

Paratypes. KMNH VP 100,223, an almost complete specimen with its left side exposed, but parts of dorsal and anal fins are missing. The standard length is 48.4 mm. KMNH VP 100,224, an almost complete specimen with its left side exposed, but the head region is missing. The length between the pelvic insertion and the end of the hypural is 36.8 mm. KMNH VP 100,225, an almost complete specimen with

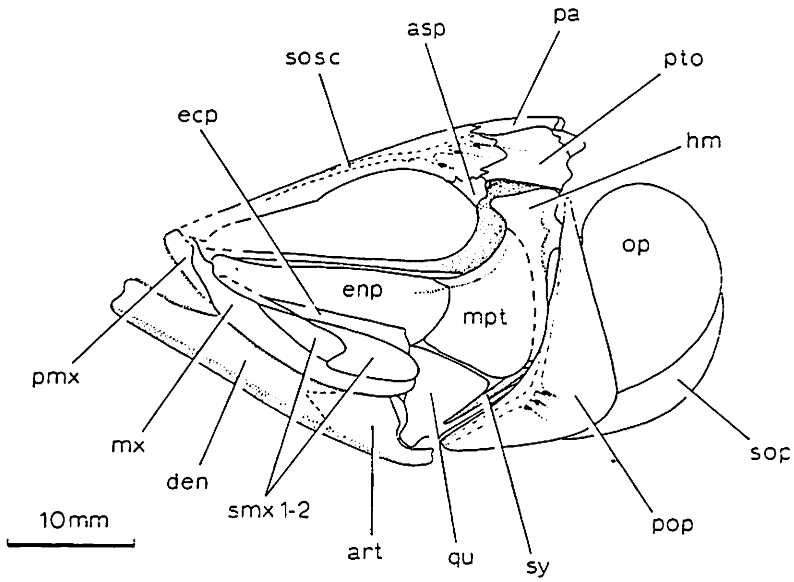

Fig. 85. *Pachythrissops laevis* WOODWARD, 1919, Cranium in left lateral view. From FOREY, 1973.

its right side exposed. The standard length is 23.8 mm. KMNH VP 100,226, an almost complete specimen with its right side exposed, but the anterior part of the head region is missing. The length from the pectoral insertion to the end of the hypural is 18.2 mm.

Locality. Minamigaoka (KM-1), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Third Formation (the upper formation, W_3, correlated to the Lower Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species is named for Mr. Naoki, KIKUCHI, who collected and donated the specimens to the Kitakyushu Museum and Institute of Natural History.

Description of the holotype.

The body is moderate and the depth is contained 3.2 times in the standard length. The head length is contained 4.0 times in the standard length. The snout is rounded. The outline of the head dorsal margin is convex. The outline from the occipital region to the dorsal origin is slightly convex. The restored outline of the abdomen is convex, and runs little under the lower end of each rib. The median fins

are relatively posterior in position. The anal origin is behind the dorsal origin and about vertical with the fifth dorsal fin pterygiophore (the anterior half of the dorsal fin base). The first dorsal fin pterygiophore is inserted between the neural spines of the first and second caudal vertebrae. The dorsal fin base is contained 1.4 times in the anal fin base. The pectoral fin is short and does not reach the pelvic insertion. The caudal fin is forked (Figs. 86 and 87). The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 17. There are 17 anal fin pterygiophores. Anterior three anal fin pterygiophores are inserted between the first and second caudal vertebrae and extend nearly vertebral column. The principal dorsal and anal fin rays are preceded by one small unbranched accessory ray respectively. The number of pectoral fin rays is 10. Five pelvic fin rays are visible. There are 18 principal caudal fin rays (1,8,8,1). The gape of the mouth is small. The lower jaw is short. The dentary bears small canine like teeth on its oral margin. The suture between the dentary and anglo-articular is not visible and the posterior part of the lower jaw is poorly preserved. The premaxilla bears small canine like teeth. There are no teeth on the maxilla. The dentary teeth are larger than the premaxillary teeth. The posterior end of the lower jaw is placed below almost center of the orbit. There are no teeth on the parasphenoid. Teeth are not visible on the endopterygoid. The frontal is short and carries a superficial canal. Parts of the opercle and preopercle are visible (Fig. 88). The total number of vertebrae is 40, with 20 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae was estimated on the basis of the ribs. The number of ribs is 18. There is a series of median supraneurals beginning immediately behind the head and ending above the first caudal vertebra. Anterior six or seven supraneurals are leaf-shape with a ridge running from a dorsal end to a ventral end and others are cylindrical. The first preural centrum bears the wide parhypural. The neural arch and spine of the first preural centrum are complete. There are 7 hypurals. The first hypural is the largest. The second hypural is about half of the first one in width. The third and second hypurals are almost same in size. There is a space between the second and third hypurals. The fourth to sixth hypurals are slender and cylindrical. There are two ural centra. The second ural centrum bears at least four hypurals (HYU3–6). One uroneural is visible. The uroneural extends to the middle of the first preural centrum. There are two epurals above the uroneural (Fig. 89).

Description of the paratypes.

In KMNH VP 100,223, the body depth is contained 3.3 times in the standard length. The head length is contained 4.3 times in the standard length. The first dorsal fin pterygiophore is inserted between the neural spines of the first and second caudal vertebrae. The dorsal fin base is contained 1.5 times in the anal fin base. There are 10 dorsal fin pterygiophores. The number of principal anal fin rays is 18.

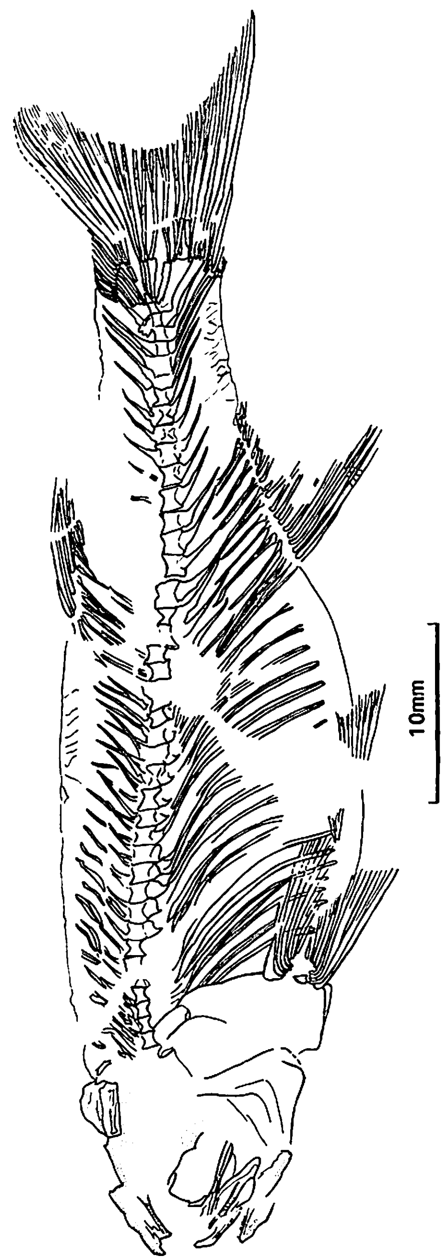

Fig. 86. *Paraleptolepis kikuchii* gen. et sp. nov., the holotype, KMNH VP 100,222.

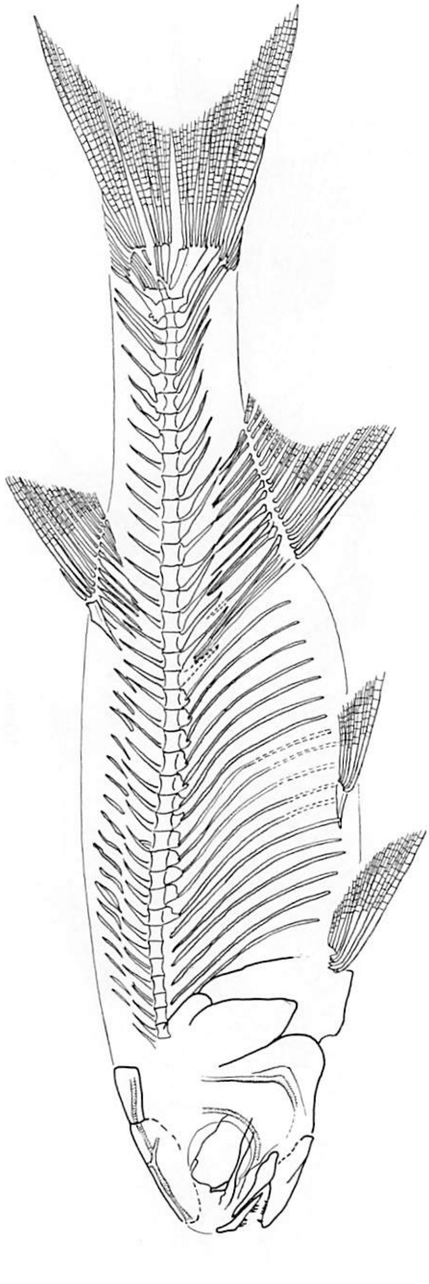

Fig. 87. *Paraleptolepis kikuchii* gen. et sp. nov., restoration of the skeleton.

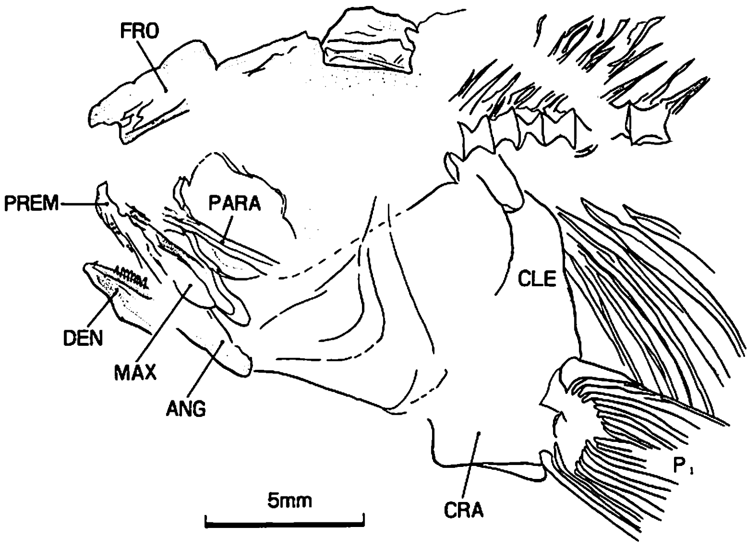

Fig. 88. *Paraleptolepis kikuchii* gen. et sp. nov., head region of the holotype, KMNH VP 100,222.

There are 19 anal fin pterygiophores. The principal anal fin rays are preceded by four small unbranched accessory rays. The number of pectoral fin rays is 11. The total number of vertebrae is 40, with 20 caudal vertebrae. The number of ribs is 18. There are three uroneurals extending over the first preural centrum.

In KMNH VP 100,224, the first dorsal fin pterygiophore is above the neural spine of the first caudal vertebra. The dorsal fin base is contained 1.5 times in the anal fin base. The number of principal dorsal fin rays is 11. There are 12 dorsal fin pterygiophores. There are 19 anal fin pterygiophores. The principal dorsal fin rays are preceded by one small unbranched accessory rays. The principal anal fin rays are preceded by three unbranched accessory rays. The number of pectoral fin rays is 11. There are 18 principal caudal fin rays (1,8,8,1). The total number of vertebrae is 40, with 20 caudal vertebrae. The number of ribs is 18.

In KMNH VP 100,225, the body depth is contained 3.7 times in the standard length. The head length is contained 3.5 times in the standard length. The first dorsal pterygiophore is above the neural spine of the second caudal vertebra. The dorsal fin base is contained 1.6 times in the anal fin base. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 18. There are 19 anal fin pterygiophores. The principal anal fin rays are preceded by four small unbranched accessory rays. The total number of vertebrae is 40, with 19 caudal vertebrae. The number of ribs is 19.

In KMNH VP 100,226, the first dorsal pterygiophore is above the neural spine of the first caudal vertebra. The dorsal fin base is contained 1.6 times in the anal fin

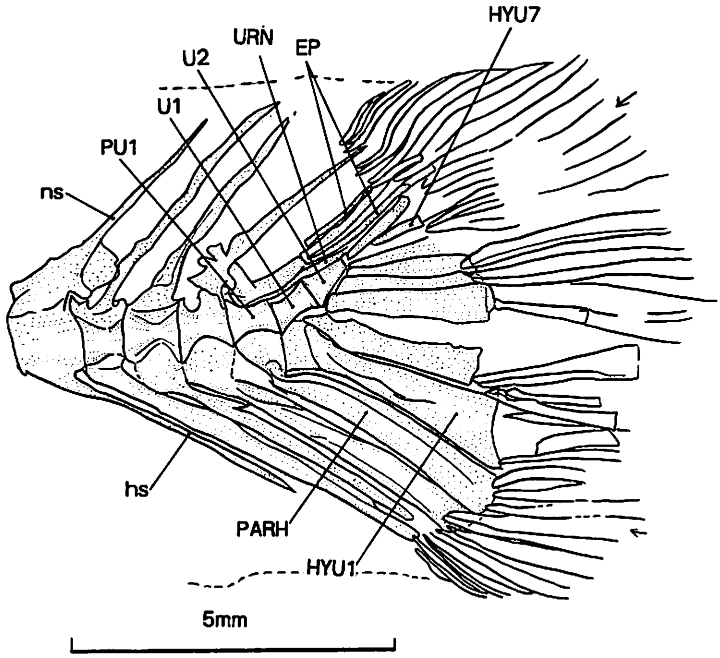

Fig. 89. *Paraleptolepis kikuchii* gen. et sp. nov., caudal skeleton of the holotype, KMNH VP 100,222

base. The number of principal dorsal fin rays is 12. The number of principal anal fin rays is 19. There are 19 anal fin pterygiophores. The principal anal fin rays are preceded by two small unbranched accessory rays. The total number of vertebrae is 42, with 20 caudal vertebrae. The number of ribs is 20.

Remarks. This new species, *Paraleptolepis kikuchii* is close to *Paraleptolepis elegans* in the meristic characters and the characters of the head and caudal regions. But it differs from *P. elegans* in the proportion. The body depth is contained 3.2 to 3.7 times in the standard length in *P. kikuchii,* 4.7 to 5.5 times in *P. elegans* (Tab. 6).

Paraleptolepis elegans sp. nov.

(Figs. 90–93, Pls. 58–59)

Diagnosis. It differs from other species of the genus in having the combination of following characters. The body is slender. The body depth is contained 4.7 to 5.5 times in the standard length. The head length is contained 4.1 to 5.1 times in the standard length. The anterior three anal fin pterygiophores do not extend near the vertebral column. The first dorsal fin pterygiophore is above the neural spine of the first caudal vertebra. The number of vertebrae is 41 to 42, with 19 to 20 caudal

Table 6. Comparison of characters in the species of the new genus *Paraleptolepis*.

	Paraleptolepis kikuchii gen. et sp. nov.	*P. elegans* gen et sp. nov.
Counts		
D.	11–12	10–12
D. pterygiophore	10–12	10–11
A.	17–19	18–19
A. pterygiophore	17–19	18–20
P_1	10–11	12
P_2	5	5–6
C.	18	19
V.	40–42 (20–22+20–19)	41–42 (22+19–20)
ribs	18–20	20
ratio		
SL/BD	3.2–3.7	4.7–5.5
SL/HL	3.5–4.3	4.1–5.1
AB/DB	1.4–1.6	4.5–2.5
other character		
Size of pelvic fin	small	middle

A., anal fin rays; AB, anal fin base; BD, body depth; C., caudal fin rays; D., dorsal fin rays; DB, dorsl fin base; HL, head length; P_1, pectoral fin rays; P_2, pelvic fin rays; SL, standard length; V., vertebrae.

vertebrae. The number of ribs is 20.

Holotype. KMNH VP 100,227, an almost complete specimen with its right side exposed, but the posterior part of the caudal fin is missing. The standard length is 48.9 mm.

Paratypes. KMNH VP 100,228, an almost complete specimen with its left side exposed, but the anterior part of the head region and the pelvic fin are missing. The length from the pelvic insertion to the posterior margin of the hypural is 30.3 mm. KMNH VP 100,229, an almost complete specimen with its right side exposed, but a part between the end of the dorsal fin base and the middle of the anal fin base is missing. The standard length is 41.0 mm. KMNH VP 100,230, an almost complete specimen with its right side exposed, but the caudal bones are missing. The length from the snout to the posterior end of the first preural centrum is 35.6 mm. KMNH VP 100,231, an almost complete specimen with its right side exposed, but the anterior end of the head and the posterior part of the caudal fin are missing. The standard length is 58.8 mm. KMNH VP 100,232, an almost complete specimen with its right side exposed, but a part of the caudal region is missing. The standard

length is 32.5 mm.

Locality. Minamigaoka (KM-1), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Third Formation (the upper formation, W_3, correlated to the Lower Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Etymology. The species name, *elegans*, means elegant.

Description of the holotype.

The body is slender. The body depth is contained 5.1 times in the standard length. The head length is contained 4.1 times in the standard length. The snout is round. The outline of the head dorsal margin is slightly convex. The outline from the occipital region to the dorsal origin is almost straight. The restored outline of the abdomen is slightly convex and runs little under the lower end of each rib. The median fins are relatively posterior in position. The anal origin is behind the dorsal origin and about vertical with the sixth dorsal fin pterygiophore. The first dorsal fin pterygiophore is above the neural spine of the first caudal vertebra (Fig. 90). The dorsal fin base is contained 1.8 times in the anal fin base. The pectoral fin is short and does not reach the pelvic insertion. The number of principal dorsal fin rays is 12. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 20. There are 20 anal fin pterygiophores. The principal anal fin rays are preceded by two small unbranched accessory rays. Twelve pectoral fin rays are visible. Five pelvic fin rays are visible. There are 18 principal caudal fin rays (1,8,8,1). The gape of the mouth is small. The mandible is short. The dentary bears small canine like teeth. The suture between the dentary and anglo-articular is not visible and the posterior part of the mandible is poorly preserved. The premaxilla bears small canine like teeth. There are no teeth on the maxilla. The posterior end of the lower jaw is placed below almost center of the orbit. There are no large teeth on the parasphenoid (Fig. 92). The total number of vertebrae is 42, with 20 caudal vertebrae. The anterior end of the vertebral column is not visible. The number of abdominal vertebrae was estimated on the basis of the ribs. The number of ribs is 20. There is a series of median supraneurals beginning immediately behind the head. Each supraneural of the anterior two-thirds is wide and leaf-shape with a ridge running from a dorsal end to a ventral end. The first and second hypurals are almost same in size. The first hypural is slightly larger than the second hypural at the anterior part. There are 6 hypurals. There is a space between the second and third hypurals. The third to sixth hypurals are slender. There are two ural centra. The second ural centrum bears at least three hypurals (HYU3–5). The uroneurals

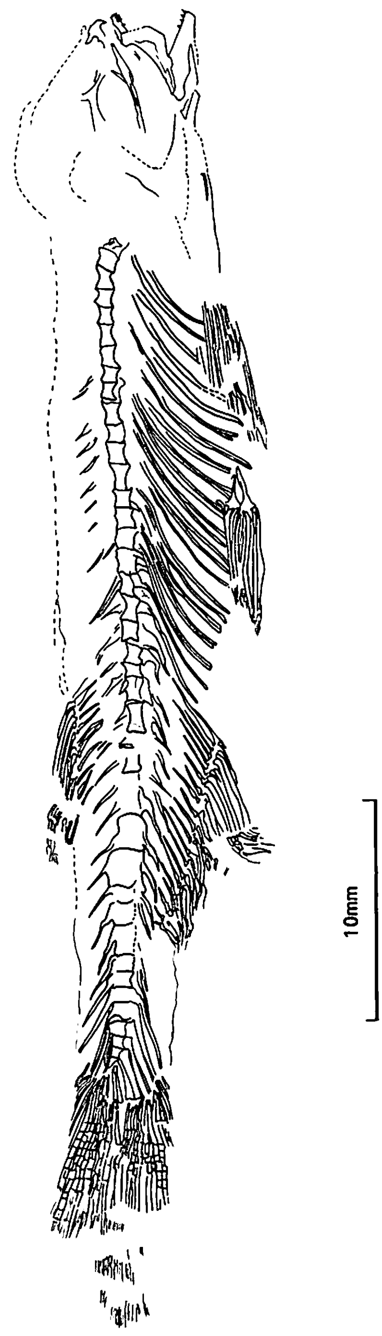

Fig. 90. *Paraleptolepis elegans* gen. et sp. nov., the holotype, KMNH VP 100,227.

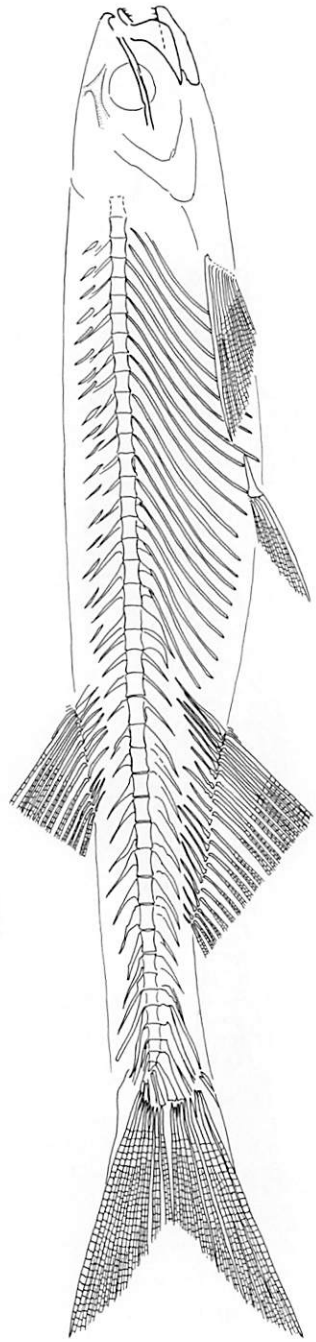

Fig. 91. *Palaleptolepis elegans* gen. et sp. nov., restoration of the skeleton.

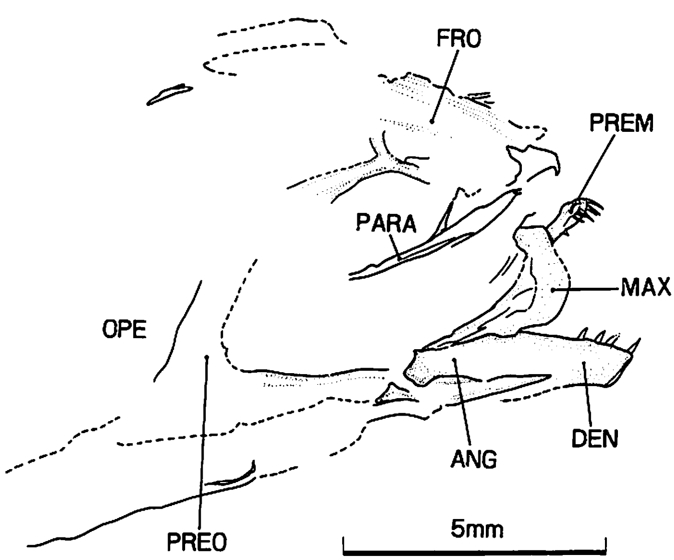

Fig. 92. *Paraleptolepis elegans* gen. et sp. nov., head region of the holotype, KMNH VP 100,227.

extend forward to the first preural centrum. The epural is not visible (Fig. 93).

Description of the paratypes.

In KMNH VP 100,228, the first dorsal fin pterygiophore is above the neural spine of the first caudal vertebra. The dorsal fin base is contained 1.5 times in the anal fin base. The number of principal dorsal fin rays is 12. There are 11 dorsal fin pterygiophores. There are 18 anal fin pterygiophores. The principal dorsal fin rays are preceded by two small unbranched accessory rays. The anal fin rays are preceded by three small unbranched accessory rays. Six pelvic fin rays are present. The total number of vertebrae is 41, with 19 caudal vertebrae. The number of ribs is 20.

In KMNH VP 100,229, the body depth is contained 5.5 times in the standard length. The head length is contained 4.8 times in the standard length. The first dorsal fin pterygiophore is above the neural spine of the first caudal vertebra. The dorsal fin base is contained 2.2 times in the anal fin base. There are 20 anal fin pterygiophores. The principal anal fin rays are preceded by four small unbranched accessory rays. The total number of vertebrae is 42, with 20 caudal vertebrae. The number of ribs is 20.

In KMNH VP 100,230, the first dorsal pterygiophore is above the first caudal vertebra. The dorsal fin base is contained 2.5 times in the anal fin base. The number of principal dorsal fin rays is 10. There are 10 dorsal fin pterygiophores. The number of principal anal fin rays is 18. There are 19 anal fin pterygiophores.

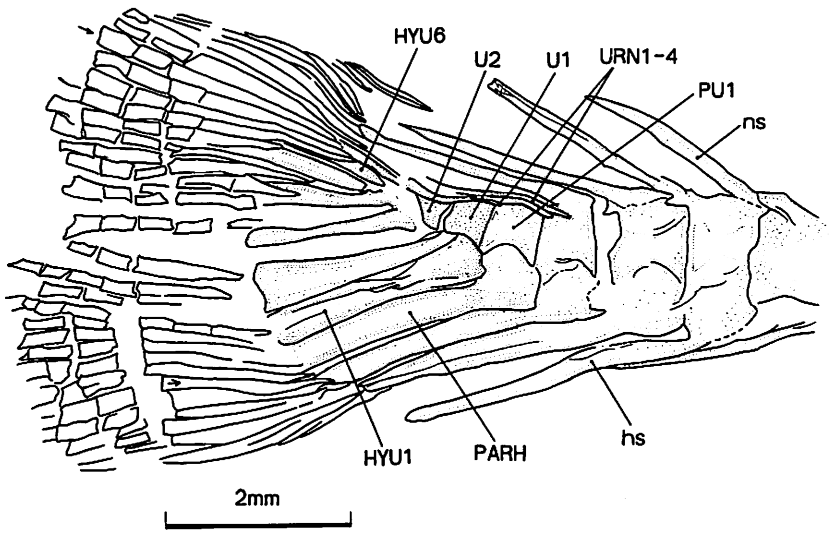

Fig. 93. *Paraleptolepis elegans* gen. et sp. nov., caudal skeleton of the holotype, KMNH VP 100,227.

The principal anal fin rays are preceded by two small unbranched accessory rays. There are villiform teeth on the endopterygoid. The total number of vertebrae is 40, with 20 caudal vertebrae. Sixteen ribs can be counted.

In KMNH VP 100,231, the body depth is contained 4.7 times in the standard length. The head length is contained 5.1 times in the standard length. The dorsal fin base is contained 1.8 times in the anal fin base. There are 19 anal fin pterygiophores. The principal anal fin rays are preceded by four small unbranched accessory rays. The number of pectoral fin rays is 11. The total number of vertebrae is 42, with 20 caudal vertebrae. The number of ribs is 20. There are two ural centra. There are four uroneurals. The first uroneural extends to the second preural centrum. The second and third uroneurals extend to the first preural centrum. The fourth uroneural extends to the first ural centrum.

In KMNH VP 100,232, the body depth is contained 7.2 times in the standard length. The head length is contained 4.1 times in the standard length. The dorsal fin base is contained 2.1 times in the anal fin base. The preopercle is L-shape. The number of principal dorsal fin rays is 11. There are 11 dorsal fin pterygiophores. The number of principal anal fin rays is 18. There are 19 anal fin pterygiophores. The principal dorsal and anal fin rays are preceded by four small unbranched accessory rays. The total number of vertebrae is 42, with 20 caudal vertebrae. The number of ribs is 20.

Remarks. This new species, *Paraleptolepis elegans*, is close to *Paraleptolepis kikuchii* in

meristic characters and the characters of the head and caudal regions, but it differs from *P. kikuchii* in the proportion. The body is slender and the depth is contained 4.7 to 5.5 times in the standard length in *P. elegans,* 3.2 to 3.7 times in *P. kikuchii* (Tab. 6).

Order Gonorynchiformes ?
Family *incertae sedis*
(Figs. 94–95, Pl. 59)

Specimen. KMNH VP 100,233, a specimen with its left side exposed. The head region is missing. The length from the dorsal origin to the posterior end of the hypural is 16.2 mm. The estimated standard length is 32.5 mm.

Locality. Minamigaoka (KM-1), Kokura-kita-ku (Kokura Northern Ward), Kitakyushu City, Fukuoka Prefecture, Japan.

Horizon. The Third Formation (the upper formation, W_3, correlated to the Lower Wakamiya Formation) of the Wakino Subgroup in the Kwanmon Group, the Lower Cretaceous.

Description.

The body is slender. The body depth is contained 7.6 times in the estimated standard length. The outline from the occipital region to the dorsal origin is straight. The dorsal fin is situated at about the middle of the body. The pelvic fin is large and is situated below the dorsal fin (Fig. 94, Pl. 59). The first dorsal fin pterygiophore is inserted between the neural spines of the eighth and ninth abdominal vertebrae. The dorsal fin is large and the base is longer than the anal fin base. The anal fin base is contained 1.6 times in the dorsal fin base. The pectoral fin is large and extends below the dorsal origin. The origin of the anal fin is behind the end of the dorsal fin base. The caudal fin is forked. The number of principal dorsal fin rays is 12. There are 12 dorsal fin pterygiophores. The number of principal anal fin rays is 11. There are 11 anal fin pterygiophores. Twelve pectoral fin rays are visible. Seven pelvic fin rays are visible. There are 19 principal caudal fin rays (1,9,8,1). The total number of vertebrae is 35, with 18 caudal vertebrae. There is a series of median supraneurals beginning immediately behind the head and ending before the dorsal origin. Each supraneural is cylindrical. The neural arch and spine of the first preural centrum are complete. There are 6 hypurals. The first hypural is the largest. The second hypural is about half of the first one in width and does not extend to the first ural centrum. There is a space between the second and third hypurals. There are two ural centra. The second ural centrum bears three hypurals (HYU3–5). One uroneural is visible and extends forward to the first

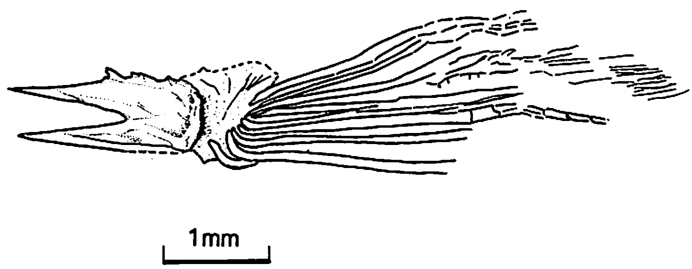

Fig. 94. Teleostei *incertae sedis*, the pelvic fin and basipterygium of KMNH VP 100,233.

ural centrum. One large epural is present (Fig. 95).

Remarks. This fish is characterized by following characters. The dorsal fin is situated at about the middle of the body. The dorsal fin is large and the base is longer than the anal fin base. The pectoral fin is large and extends below the dorsal origin. The pelvic fin is large and is situated below the dorsal fin. Two ural centra are present. The neural spine and arch of the first preural centrum are complete. One wide epural is present. The number of branched caudal fin rays is 17 (1,9,8,1). The number of vertebrae is 35, with 18 caudal vertebrae.

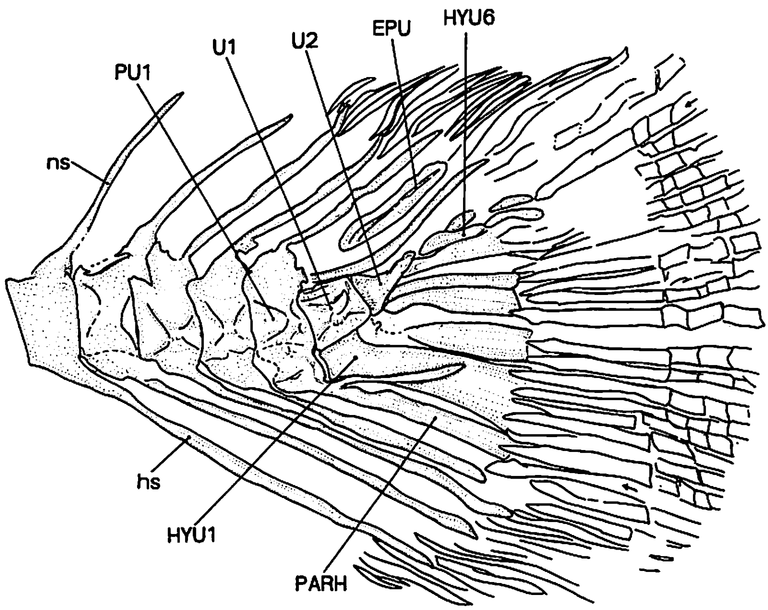

Fig. 95. Teleostei *incertae sedis*, caudal skeleton of KMNH VP 100,233.

Fishes of the order Gonorynchiformes have the slender body, large dorsal fin and large pectoral fin below the dorsal fin. Anal fin base is shorter than the dorsal fin base. The dorsal fin is large and the length of the dorsal fin base is longer than the anal fin base in the order Gonorynchiformes. The large pelvic fin is situated below the dorsal origin in the families Gonorynchidae and Kneriidae (NELSON, 1984). The number of branched caudal fin rays is 17 (1,9,8,1) and one epural is present in the order Gonorynchiformes. (FUJITA, 1990).

The character of the position of the fins and the caudal skeleton of this species indicates the relationship to the order Gonorynchiformes.

Faunal comparison

Faunal comparison in the Wakino Subgroup.

The present author recognized three different paleoichthyofaunas in the fishes of the Wakino Subgroup. The first fauna are found in the First Formation (W_1) which correlates to the Sengoku Formation. This fauna is constituted of *Lepidotes macropterus* of the order Semionotiformes, *Nipponamia satoi* of the Amiiformes, *Chuhsiungichthys yanagidai* of the Ichthyodectiformes, and *Aokiichthys toriyamai, A. changae, A. otai, A. uyenoi, A. praedorsalis,* and *A.* sp. of the Osteoglossiformes. Among them, fishes of the genus *Aokiichthys* of the order Osteoglossiformes are most abundant in numbers of species and individuals. The individuals of *L. macropterus, N. satoi* and *C. yanagidai* are quite few in number. The present author proposes to designate this fish fauna as the *Nipponamia-Aokiichthys* fauna.

The second fish fauna is found in the Third Formation (W_3) which correlates to the Lower Wakamiya Formation. This fauna is composed of *Paraleptolepis kikuchii* and *P. elegans* of the order and family *incertae sedis, Chuhsiungichthys* sp. of the Ichthyodectiformes, and *Wakinoichthys aokii* and *W. robustus* of the Osteoglossiformes. Fishes of the genus *Paraleptolepis* and *Wakinoichthys* are abundant in numbers of species and individuals. The osteoglossiform fishes, *W. aokii* and *W. robustus* are different from the osteoglossiform fishes of the *Nipponamia-Aokiichthys* fauna. The present author proposes to designate this fish fauna as the *Paraleptolepis-Wakinoichthys* fauna.

The third fauna is found in the Fourth Formation (W_4) which correlates to the Upper Wakamiya Formation. This fish fauna is composed of *Chuhsiungichthys japonicus* of the order Ichthyodectiformes, *Yungkangichthys macrodon* and *Wakinoichthys aokii* of the Osteoglossiformes, and *Diplomystus primotinus, D. kokuraensis, D. altisomus* and *D.* sp. of the Clupeiformes. Fishes of the genus *Diplomystus* are most abundant in number of species and individuals. Individuals of *Chuhsiungichthys* and *Yungkangichthys* are few in number. *Wakinoichthys aokii* is the second most abundant in this fauna. The present author proposes to designate this fish fauna as the *Diplomystus-Wakinoichthys* fauna.

Fish faunas of the Wakino Subgroup are composed of the primitive halecostome

orders Semionotiformes and Amiiformes, and the primitive teleostean orders Ichthyodectiformes, Osteoglossiformes and Clupeiformes. The osteoglossiform fish and clupeiform fish are most abundant in numbers of species and individuals. There are nine species belonging to 3 genera and 2 families of the order Osteoglossiformes, and 4 species belonging to the Clupeiformes. The present author proposes to designate the entire fish fauna of the Wakino Subgroup as the Wakino fish fauna (Tab. 7).

The *Nipponamia-Aokiichthys* fauna is entirely different from other fish faunas of the Wakino Subgroup and it does not have any species in common with other faunas. Only genus *Chuhsiungichthys* of the order Ichthyodectiformes is common to other faunas, but the species is different (Fig. 96, Tab. 8).

The *Paraleptolepis-Wakinoichthys* fauna has a species, *Wakinoichthys aokii,* in common with the *Diplomystus-Wakinoichthys* fauna. The *Diplomystus-Wakinoichthys* fauna is similar to the *Paraleptolepis-Wakinoichthys* fauna except for *Diplomystus* and *Paraleptolepis.* There is a possibility that *Diplomystus* originally came from the sea, for *Diplomystus* has primitive characters in the predorsal scute, rounded anterior and posterior ends and an unremarkable median crest of the predorsal scute, which suggest their origin in the sea.

Comparison with Cretaceous freshwater fish faunas in China.

CHANG and CHOW (1986) roughly grouped fossil fishes from the Late Mesozoic and Cenozoic in China into seven assemblages according to their composition and distribution.

Among them, the fish fauna of the Wakino Subgroup resembles the *Mesoclupea* assemblage (assemblage 2) from the Zhejiang, Anhui, Jiangxi, Fujian and other provinces in southeastern China. There are several families and genera common to both faunas. Four families, Semionotidae, Amiidae, Chuhsiungichthiidae and Lycopteridae, and two genera, *Lepidotes* and *Yungkangichthys* are common to both faunas. But the Hiodontidae, Ellimmichthiidae and Huashiidae of the *Mesoclupea* assemblage are absent in the Wakino fish faunas. Two families, Wakinoichthiidae and Clupeidae, of the Wakino Subgroup are not found in the *Mesoclupea* assemblage.

Among the Wakino fish faunas, the *Nipponamia-Aokiichthys* fauna is closest to the *Mesoclupea* assemblage in the existence of fishes of the families Semionotidae and Amiidae. *Lepidotes macropterus* is close to *Neolepidotes yungkangensis* and *Sinolepidotus chekiangensis* WEI, 1976. *Aokiichthys* is close to *Paralycoptera* except for the number of vertebrae. *Nipponamia* is related to *Sinamia* and *Ikechaoamia.* But the three families, Hiodontidae, Ellimmichthiidae and Huashiidae, are absent in *Nipponamia-Aokiichthys* fauna.

MA and SUN (1988) separated the Early Cretaceous fish fauna in the Jiling and Zhejiang Provinces of China into four faunas on the basis of their stage, composition and distribution. These are the *Lycoptera-Asiatolepis-Huashia* fauna in the Jiling

Table 7. The Wakino fish fauna of the Wakino Subgroup in Kyushu, Japan

Class Osteichthyes
Subclass Actinopterygii
Infraclass Neopterygii
Division Halecostomi
  Order Semionotiformes
    Family Semionotidae
      Genus *Lepidotes* AGASSIZ, 1837
        Lepidotes macropterus sp. nov.
Subdivision Halecomorphi
  Order Amiiformes
    Family Amiidae
      Genus *Nipponamia* nov.
        Nipponamia satoi sp. nov.
Subdivision Teleostei
  Order Ichthyodectiformes
    Family Chuhsiungichthiidae nov.
      Genus *Chuhsiungichthys* LIU, 1974
        Chuhsiungichthys yanagidai sp. nov.
        Chuhsiungichthys japonicus sp. nov.
        Chuhsiungichthys sp.
Infradivision Osteoglossomorpha
  Order Osteoglossiformes
    Family Lycopteridae
      Genus *Yungkangichthys* CHANG & CHOU, 1974
        Yungkangichthys macrodon sp. nov.
      Genus *Aokiichthys* nov.
        Aokiichthys toriyamai sp. nov.*
        Aokiichthys changae sp. nov.
        Aokiichthys otai sp. nov.
        Aokiichthys uyenoi sp. nov.
        Aokiichthys praedorsalis sp. nov.
        Aokiichthys sp.
    Family Wakinoichthiidae nov.
      Genus *Wakinoichthys* nov.
        Wakinoichthys aokii sp. nov.
        Wakinoichthys robustus sp. nov.
Infradivision Clupeomorpha
  Order Clupeiformes
    Family Clupeidae
      Genus *Diplomystus* COPE, 1877
        Diplomystus primotinus UYENO, 1979
        Diplomystus kokuraensis UYENO, 1979
        Diplomystus altisomus sp. nov.
        Diplomystus sp.
Teleostei Order and Family *incertae sedis*
      Genus *Paraleptolepis* nov.
        Paraleptolepis kikuchii sp. nov.
        Paraleptolepis elegans sp. nov.
  Gonorynchiformes? *incertae sedis*

Table 8. Faunal comparison within the Wakino Subgroup

The First Formation (W_1)	The Third Formation (W_3)	The Fourth Formation (W_4)
OSTEICHTHYES		
ACTINOPTERYGII		
Order Semionotiformes		
Family Semionotidae		
Lepidotes macropterus		
Order Amiiformes		
Family Amiidae		
Nipponamia satoi		
TELEOSTEI		
Order Ichthyodectiformes		
Family Chuhsiungichthiidae		
Chuhsiungichthys yanagidai	*Chuhsiungichthys* sp.	*Chuhsiungichthys japonicus*
Order Osteoglossiformes		
Family Lycopteridae		
Aokiichthys toriyamai		
Aokiichthys changae		
Aokiichthys otai		
Aokiichthys uyenoi		
Aokiichthys praedorsalis		
Aokiichthys sp.		
		Yungkangichthys macrodon
	Family Wakinoichthiidae	
	Wakinoichthys aokii	*Wakinoichthys aokii*
	Wakinoichthys robustus	
Order Clupeiformes		
		Family Clupeidae
		Diplomystus primotinus
		Diplomystus kokuraensis
		Diplomystus altisomus
		Diplomystus sp.
	Order and family *incertae sedis*	
	Paraleptolepis kikuchii	
	Paraleptolepis elegans	
	Gonorynchiformes? *incertae sedis*	

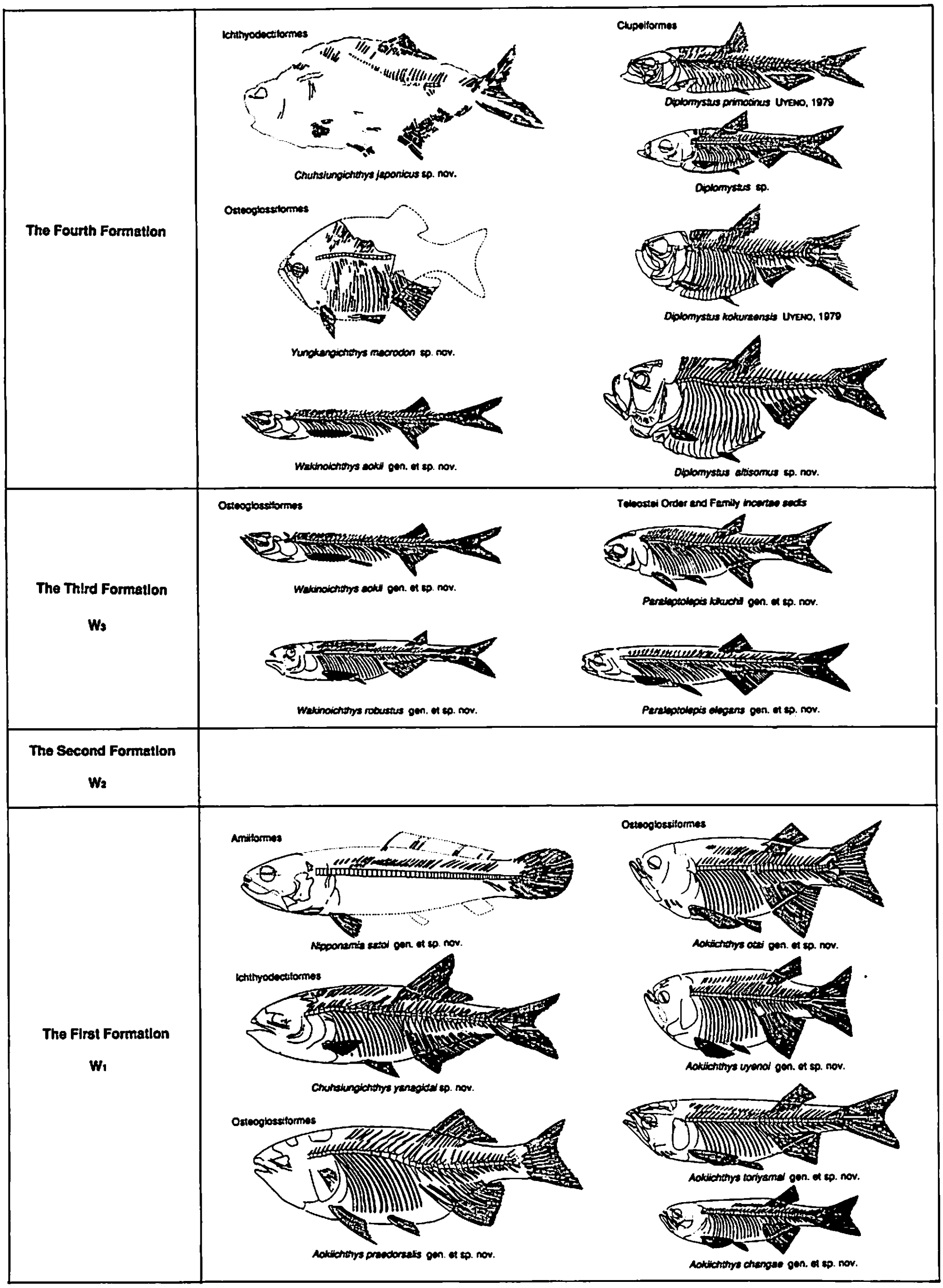

Fig. 96. Faunal comparison within the Wakino Subgroup.

Table 9. Faunal comparison between the Wakino Subgroup and the Early Cretaceous beds of southeastern China

Southeastern China	The First Formation (W_1)	The Third Formation (W_3)	The Fourth Formation (W_4)
OSTEICHTHYES			
ACTINOPERYGII			
Order Semionotiformes			
Family Semionotidae			
Neolepidotes yungkangensis	*Lepidotes macropterus*		
Sinolepidotes chekiangensis			
Order Amiiformes			
Family Amiidae			
Sinamia huananensis	*Nipponamia satoi*		
Ikechaoamia meridionalis			
TELEOSTEI			
Order "Leptolepiformes"			
Family "Leptolepidae"			
Pingolepis polyurocentralis			
Fuchunkiangia chesiensis			
Order Ichthyodectiformes			
Family Chuhsiungichthiidae			
Mesoclupea showchangensis	*Chuhsiungichthys yanagidai*	*Chuhsiungichthys* sp.	*Chuhsiungichthys japonicus*
Chuhsiungichtrhys tsanglingensis			
Order Osteoglossiformes			
Family Lycopteridae			
Paralycoptera wui	*Aokiichthys toriyamai*		
	Aokiichthys changae		
	Aokiichthys otai		
	Aokiichthys uyenoi		
	Aokiichthys praedorsalis		
	Aokiichthys sp.		
Yungkangichthys hsitanensis			*Yungkangichthys macrodon*
Family ?Hyodontidae			
Chetungichthys brevicephalus			
		Family Wakinoichthiidae	
		Wakinoichthys aokii	*Wakinoichthys aokii*
		Wakinoichthys robustus	
Order Ellimmichthiiformes			
Family Ellimmichthyidae			
Paraclupea chetungensis			
Order Clupeiformes			
			Family Clupeidae
			Diplomystus primotinus
			Diplomystus kokuraensis
			Diplomystus altisomus
			Diplomystus sp.
Order			
Family Huashiidae			
Huashia gracilis			
Order and family incertae sedis			
		Paraleptolepis kikuchii	
		Paraleptolepis elegans	
Gonorynchiformes?			
		incertae sedis	

Province and the *Mesoclupea-Huashia* fauna in the Zhejiang Province at the early stage of Early Cretaceous, and *Paralycoptera-Tonghuaichthys-Huashia* fauna in the Jiling Province and the *Paralycoptera-Pingolepis-Huashia* fauna in the Zhejiang Province at the early to middle stage of the Early Cretaceous. The *Nipponamia-Aokiichthys* fauna is related to the faunas of the early to middle stage of Early Cretaceous in China on the basis of its resemblance in composition.

Paraleptolepis-Wakinoichthys fauna has a family, Chuhsiungichthiidae, in common with the *Mesoclupea* assemblage, but there is no similarity between the fauna at the level of genera and species. *Diplomystus-Wakinoichthys* fauna has a genus, *Yungkangichthys*, in common with the *Mesoclupea* assemblage, but other members are quite different. The *Paraleptolepis-Wakinoichthys* and *Diplomystus-Wakinoichthys* faunas differ from the *Mesoclupea* assemblage (Tab. 9). The *Paraleptolepis-Wakinoichthys* and *Diplomystus-Wakinoichthys* faunas are considered to be endemic.

Comparison with other Cretaceous freshwater fish faunas in the world.

There are several freshwater fish faunas from the Lower Cretaceous in the world. In Spain, nineteen species belonging to 13 families and 10 orders are described from the Lower Cretaceous sediments of Las Hoyas and Montsec (Poyato-Ariza and Wenz, 1990; Sanz *et al.*, 1988). The family Amiidae and the genus *Lepidotes* are common to the Las Hoyas and Montesech fauna and the Wakino fish fauna. The elasmobranch order Hybodontiformes, the primitive halecostome orders Pycnodontiformes and Macrosemiiformes, the primitive teleostean orders Pholidophoriformes and Elopiformes, and Coelacanthiformes are present in the Las Hoyas and Montsec fauna, but they are absent in the Wakino fish fauna. The orders Ichthyodectiformes, Osteoglossiformes and Clupeiformes are present in the Wakino fish fauna, but they are absent in the Las Hoyas and Montsec fish fauna.

The Wealden freshwater fish fauna in Belgium has an order, Amiiformes, and a genus, *Lepidotes*, common to the Wakino fish fauna. But the Wealden fish fauna is characterized by the existence of the chondrostean family Coccolepididae and an abundance of amiiform fish in number of species (Traquair, 1911). The order Osteoglossiformes which is abundant in the Wakino fish fauna is absent in the Wealden fauna.

The fish fauna of Koonwarra in Australia is composed of 6 species belonging to 5 families and 5 orders (Waldman, 1971). The order Clupeiformes is common to the Koonwarra fish fauna and the Wakino fish fauna. However, the chondrostean family Coccolepididae and the primitive teleostean order Pholidophoriformes are present in the Koonwarra fauna and the existence of the lungfish family Ceratodontidae is characteristic of the Koonwarra fauna. These families and orders are absent in the Wakino fish fauna. The order Osteoglossiformes is absent in the Koonwarra fauna.

The fish fauna of the Cocobeach Series of Gabon and Equatorial Guinea in

Africa is constituted of about 10 species belonging to 8 families and orders (PATTERSON, 1975). The fish fauna of the Ilhas Formation in Brazil is composed of 12 species belonging to 7 families and orders (SCHAEFFER, 1947) and is similar to the fauna of the Cocobeach Series of Gabon and Equatorial Guinea. Both faunas are characterized by the existence of the orders Coelacanthiformes and Aspidorhynchiformes and an abundance of the Ichthyodectiformes and the Leptolepiformes in number of species. The semionotid genus *Lepidotes* is more abundant and the order Gonorynchiformes is absent in the Ilhas Formation. The orders Amiiformes and Ichthyodectiformes are common to the Wakino fish fauna and the faunas of the Cocobeach Series of Gabon and Equatorial Guinea and the Ilhas Formation.

The orders Coelacanthiformes, Aspidorhynchiformes, and Ellimmichthiiformes are present in the fauna of the Cocobeach Series of Gabon and Equatorial Guinea and the Ilhas Formation, but these orders are absent in the Wakino fish fauna. The orders Osteoglossiformes and Clupeiformes which are abundant in the Wakino fish fauna are absent in the faunas of the Cocobeach Series of Gabon and Equatorial Guinea, and the Ilhas Formation.

The osteoglossiform fish is not recognized in the Lower Cretaceous fish faunas except in southeastern China and the clupeiform fish is not so abundant in the Lower Cretaceous freshwater deposits in the world. The Wakino fish fauna is characterized by an abundance of the orders Osteoglossiformes and Clupeiformes and the absence of the orders Coccolepiformes, Pholidophoriformes, Macrosemiiformes and Pycnodontiformes, and the family Huashiidae (Tab. 10).

Concluding Remarks

1. Comparison of faunal changes of the molluscan fossils and the fish fossils in the Wakino Subgroup.

Y. OTA (1960b) subdivided the Wakino Subgroup distributed in the northern part of Kyushu Island into two zones based on molluscan fossils: the lower, *Brotiopsis wakinoensis* Zone (the lower formation, W_1, the First Formation) and the upper, *Viviparus onogoensis-Nakamuranaia* (?) sp. cf. *N. chingshanensis* Zone. The upper zone is subdivided into three zones: the middle, upper and uppermost formations which correspond to the Second (W_2), Third (W_3) and Fourth (W_4) Formations respectively on the basis of the distribution of molluscan fossils (Fig. 3). In the First Formation, *Brotiopsis wakinoensis* is most abundant and *Plicatounio naktongensis* occurs commonly. "*Nippononaia*" *wakinoensis*, "*N.*" *sengokuensis*, *Plicatounio naktongensis multiplicatus*, *P. triangularis* and *P. kwanmonensis* are very rare in the First Formation (W_1). In the Second Formation (W_2), a few molluscan fossils, *Viviparus onogoensis* and others, are found from Nogata and Moji in northern part of Kyushu and Yoshimo in Yamaguchi Prefecture. Molluscan fossils of *Brotiopsis kobayashii*, *Viviparus onogoensis* and *Sphaerium* (?) sp., and Ostracoda are found at Takatsuo in Kokura-minami-ku in

Table 10. Comparison of Late Mesozoic freshwater fish faunas of the world (WALDMAN, 1971; PATTERSON, 1975; CHANG and CHOW, 1986; SANZ *et al.*, 1988; POYATO-ARIZA and WENZ, 1990)

Southeasterm China	Wakino fish fauna, Japan.	Las Hoyas and Montsec, Spain	Bernissart, Belgium	Koonwarra, Australia	Cocobeach Series of Gabon and Equatorial Guinea, Africa	Ilhas Formation, Brazil
CHONDRICHTHYES						
Order Hybodontiformes		Order Hybodontiformes				
		Family Hybodontidae				
		Hybodus woodwardi				
OSTEICHTHYES						
ACTINOPTERYGII						
CHONDROSTEI						
Order Paleonisciformes			Order Paleonisciformes	Order Paleoniscifromes		
			Family Coccolepididae			
			Coccolepis mcropterus	*Coccolepis woodwardi*		
HOLOSTEI				*?Coccolepis* sp.		
Order Pycnodontiformes		Order Pycnodontiformes				
		Family Gyrodontidae				
		Proscenetes sp.				
		Family Pycnodontidae				
		Coelodus sp.	*Macromesodon bernissartensis*			
		Genus *incertae sedis*				
Order Semionotiformes		Order Smionotiformes			Order Semionotiformes	
Family Semionotidae						
Neolepidotes yungkangensis	*Lepidotes macropterus*	*Lepidotes* sp.	*Lepidotes bernissartensis*		*Lepidotes* sp.	*Lepidotes mawsoni*
Sinolepidotes chekiangensis						*L. souzai*
						L. roxoi
Order Macrosemiiformes		Order Macrosemiiformes				
		Family Mcrosemiidae				
		Notagogus ferrerei				
		N. sp.				
		Family Ophiopsidae				
		Ophiopsis montsechensis				
		Proterus vidali				
Order Amiiformes		Order Amiiformes			Order Amiiformes	
Family Amiidae		Family Amiidae			Family Amiidae	
Sinamia huananensis	*Nipponamia satoi*	*Vidalamia catalunica*	*Amiopsis lata*			
Ikechaoamia meridionalis		*Urocles woodwardi*	*A. dolloi*		*Urocles* sp.	*Urocles mawsoni*
		?Amiopsis sp.				
		Family Caturidae	Family Furidae			
		Caturus sp.	*Callopterus insignis*			
Order Aspidorhynchiformes					Order Aspidorhynchiformes	
					Family Aspidorthynchidae	
					Belonostomus sp.	*Belonostomus carinatus*
TELEOSTEI						
Order Pholidophoriformes		Order Pholidophoriformes		Order Pholidophoriformes		
		Family Pleuropholidae		Family Archaeomaenidae		
		Pleuropholis sp.		*Wadichthys oxyops*		
Order "Leptolepiformes"		Order "Leptolepiformes"		Order "Leptolepiformes"	Order "Leptolepiformes"	
Family "Leptolepidae"		Family "Leptolepidae"			Family "Leptolepididae"	
Pingolepis polyurocentralis		*?Ascalabos voithi*	*Aethalionopsis robustus*		*Leptolepis congolensis*	*Leptolepis bahiaensis*
Fuchunkiangia chesiensis		*Leptolepis crusafonti?*		*Leptolepis koonwarri*	*Clupavus* spp.	*Scombroclupeoides scutata*
Order Ichthyodectiformes					Order Ichthyodectiformes	
Family Chuhsiungichthiidae					Family Ichthyodectidae	
Mesoclupea showchangensis	*Chuhsiungichthys yanagidai*				*Chirocentrites? quinensis*	*Cladocyclus mawsoni*
Chuhsiungichthys tsanglingensis	*C. japonicus*				Two undescribed ichthyodectids	*C. woodwardi*
	C. sp.					
Order Osteoglossiformes						
Family Lycopteridae						
Paralycoptera wui	*Aokiichthys toriyamai*					
	A. changae					
	A. otai					
	A. uyenoi					
	A. praedorsalis					
	A. sp.					
Yungkangichthys hsitanensis	*Yungkangichthys macrodon*					
Family ?Hyodontidae						
Chetungichthys brevicephalus						
	Family Wakinoichthiidae					
	Wakinoichthys aokii					
	W. robustus					
Order Elopiformes		Order Elopiformes				
		Family Elopidae				
		Anaethalion vidiali				
Order Ellimmichthiiformes						Order Ellimmichthiiformes
Family Ellimmichthyidae						Family Ellimmichthyidae
Paraclupea chetungensis					*Diplomystus goodi*	*Ellimmichthys longicostatus*
Order Clupeiformes				Order Clupeiformes		
	Family Clupeidae			Family Koonwarriidae		
	Diplomystus primotinus			*Koonwarria manifrons*		
	D. kokuraensis					
	D. altisomus					
	D. sp.					
Order		Order Gonorynchiformes			Order Gonorynchiformes	
Family Huashiidae		Family Chanidae			Family Chanidae	
Huashia gracilis		*Rubiesichthys gregalis*			*Parachanos aethiopicus*	
	Paraleptolepis kikuchii	Undetermined Teleostei				
	P. elegans					
	Gonorynchiformes?					
	incertae sedis					
CROSSOPTERYGII						
		Order Coelacanthiformes				
		Family Coelacanthidae			Family Coelacanthidae	
		?"Holophagus" leridae			*Mawsonia ubangiana*	*Mawsonia gigas*
						M. minor
DIPNEUSTI						
Order Ceratodontiformes				Order Ceratodontiformes		
				Family Ceratodontidae		
				Ceratodus sp.		

the northern part of Kyushu (Y. OTA and YABUMOTO, 1992). In the Third Formation (W_3), molluscan fossils become abundant. *P. naktongensis multiplicatus* and *Nakamuranaia* (?) sp. cf. *N. chingshanensis* are abundant in Wakino. *Nakamuranaia* (?) sp. cf. *N. chingshanensis* and *Viviparus onogoensis* are most abundant in Kokura and Yahata. *Brotiopsis kobayashii kobayashii* is common in the lower 200 m and *B. kobayashii sinsyuensis* is common in the upper member of the Third Formation in the eastern Kokura area. *P. naktongensis multiplicatus* and *Trigonioides paucisulcatus suzukii* are common in the lower member of the Third Formation in the western Kokura-Yahata area. Besides them, *T. paucisulcatus paucisulcatus, Brotiopsis wakinoensis, Yoshimonia katsukiensis* and *Cypridea* sp. occur in the Third Formation. The molluscan fauna of the Third Formation is distinguished from the fauna of the First Formation. The molluscan fauna of the Fourth Formation is almost same with the fauna of the Third Formation, but the number of species considerably decline (Y. OTA, 1960b). Y. OTA (1960b) considered that the difference between the lower (the First Formation) and upper zones (the Second, Third and Fourth Formations) is not great in lithofacies and biofacies and some molluscan fossils of the upper zone indicate more evolved forms than the lower zone-fossils; for examples, *P. naktongensis multiplicatus* and *B. kobayashii* in the upper formations are derived respectively from *P. naktongensis naktongensis* and *B. wakinoensis* in the First Formation.

The difference between fish faunas of the First Formation and the other upper formations (the Third and Fourth Formations) is great and the species derived from fishes of the First Formation are absent in the Third and Fourth Formations.

The difference between the Third Formation and the Fourth Formation is not clear in the molluscan faunas, but the difference of fish fauna is clear between the Third and Fourth Formations.

Y. OTA (1960b) thought that the difference of molluscan faunas between the lower (W_1) and upper (W_2-W_4) zones may be due to a shift of time rather than to change of environment. The present author fundamentally agrees with his view. The molluscan fauna is abundant in the First Formation and the Third Formation, but it is poor in the Second Formation. No fish fossils have been found in the Second Formation. Y. OTA (1960b) regarded the Second Formation as representing the age of transgression and volcanic activity and also the age of a remarkable faunal change. Almost all fishes and some molluscs were extinct in the period of the Second Formation. This extinction would have a great influence on the faunal changes in this lake, Kowakino-ko.

2. Restoration of changes of the ancient lake, Kowakino-ko, on the basis of the fish faunas.

The Wakino fish fauna resembles faunas of the same age of the southeastern China. There are many localities in the southeastern China, but the stratigraphic correlation of these localities is not clear (CHANG and CHOU, 1977). Since the

stratigraphic correlation of fish fossil localities in the Wakino Subgroup is clear, the changes of the ancient lake, Kowakino-ko, which covered the area from the present northern part of Kyushu to the western part of Yamaguchi Prefecture, can be restored on the basis of the changes of fish faunas in the Wakino Subgroup.

In the period of the First Formation, the fauna of the Kowakino-ko Lake was similar to faunas of the lakes of the southeastern China in some extent, because the *Nipponamia-Aokiichthys* fauna slightly resembles the fauna of the early to middle stage of the Early Cretaceous in the southeastern China. The fishes of this period of the Kowakino-ko Lake became extinct at the end of the First Formation or the beginning of the Second Formation, because no fish fossils have been found in the Second Formation, and the fish fauna of the First Formation is entirely different from other two faunas.

The Second Formation represents the age of volcanic activity (Y. OTA, 1960b). The fishes of the Third Formation had developed without relation to the fishes of the First Formation in a period of volcanic inactivity after the extinction of the fishes of the First Formation.

Most fishes of the *Paraleptolepis-Wakinoichthys* fauna became extinct at the end of the Third Formation. There is a possibility that the clupeid fishes of the Fourth Formation came into the lake from the sea at the beginning of the period of the Fourth Formation and take place of the most abundant fish, *Paraleptolepis* of the *Paraleptolepis-Wakinoichthys* fauna. *Wakinoichthys* survived in the period of the Fourth Formation. Ichthyodectiform fishes, *Chuhsiungichthys,* appear in all fish faunas of the Wakino Subgroup. Most members of the Ichthyodectiformes are marine and some fossils are found in brackish and freshwater deposits. Fishes of the genus *Chuhsiungichthys* of each formation are considered to be originated in marine or brackish water ichthyodectiform fish.

Ostracoda and conchostracan fossils are yielded from the Third and Fourth Formations with fish fossils, but they are not found from the First Formation at the Tokuriki fish fossil site. Extant conchostracans live in shallow water. The existence of conchostracan fossils indicates that the depth of water at fossil sites of the Third and Fourth Formations are shallow, and the absence indicates that the fossil site of the First Formation is comparatively deep. Many juvenile fish are yielded from the site of the Third Formation with numerous ostracods. This indicates that the depth of the water was shallower at the site of the Third Formation.

3. Record of freshwater fish fossils in Japan.

The Mesozoic freshwater fish fossils have been very meager in Japan with the exception of the fish fossils of the Wakino Subgroup which are described in the present study. The only record is a few fragments from the Lower Cretaceous Tetori Group in Ishikawa Prefecture. These fragments consist of one lower jaw and several isolated scales belonging to the holostean fishes (AZUMA and HASEGAWA, 1989).

In Palaeogene, the only record of a freshwater fish is a cypriniform fish from the Eocene Horokabetsu Formation of the Ishikari Series in Yubari City, Hokkaido (INOUE and UYENO, 1968).

Freshwater fish fossils become abundant in the Neogene sediments. Fish fossils from Iki Island in Nagasaki Prefecture are composed of 12 species of the order Cypriniformes, 4 species of the Perciformes, one species of the Scorpaeniformes and one species of the Mastacembelidae (HAYASHI, 1975; JORDAN, 1919; UYENO, 1980). Extant species of the Mastacembelidae is distributed in tropical Africa through Syria to the Malayan Archipelago and China, but they are not distributed in Japan. Besides these, several Miocene freshwater fishes have been found in Yamagata, Kyoto, Gifu and Mie Prefectures. Most of them belong to the order Cypriniformes.

In Pliocene, numerous isolated pharyngeal teeth of cyprinid fishes are found from the Kobiwako Group in Mie Prefecture (NAKAJIMA, 1987). Gobiid fish, *Rhinogobius giurinus*, are found from the Tôgô Formation in Kagoshima Prefecture (UYENO and IWAO, 1975).

The Pleistocene fishes are abundant in the Kusu Formation. They are constituted of one salmonid, 3 cyprinids and 2 gobiids (UYENO *et al.*, 1975; YABUMOTO, 1987). Numerous isolated pharyngeal teeth of Cypriniformes are found in the Kobiwako Group (NAKAJIMA, 1987). The cyprinid fish, *Tribolodon* sp. cf. *T. hakonensis*, is described from the early or middle Pleistocene Shiobara Group in Tochigi Prefecture (UYENO, 1967). Several species of cyprinid fishes are found from the Kusu Basin in Oita Prefecture (NAKAJIMA *et al.*, 1988).

In general, freshwater fish fossils are rare in the Mesozoic and Palaeogene sediments, but became abundant in Neogene sediments in Japan. The Wakino fish fauna represents the only significant Mesozoic freshwater fish fauna found so far in Japan.

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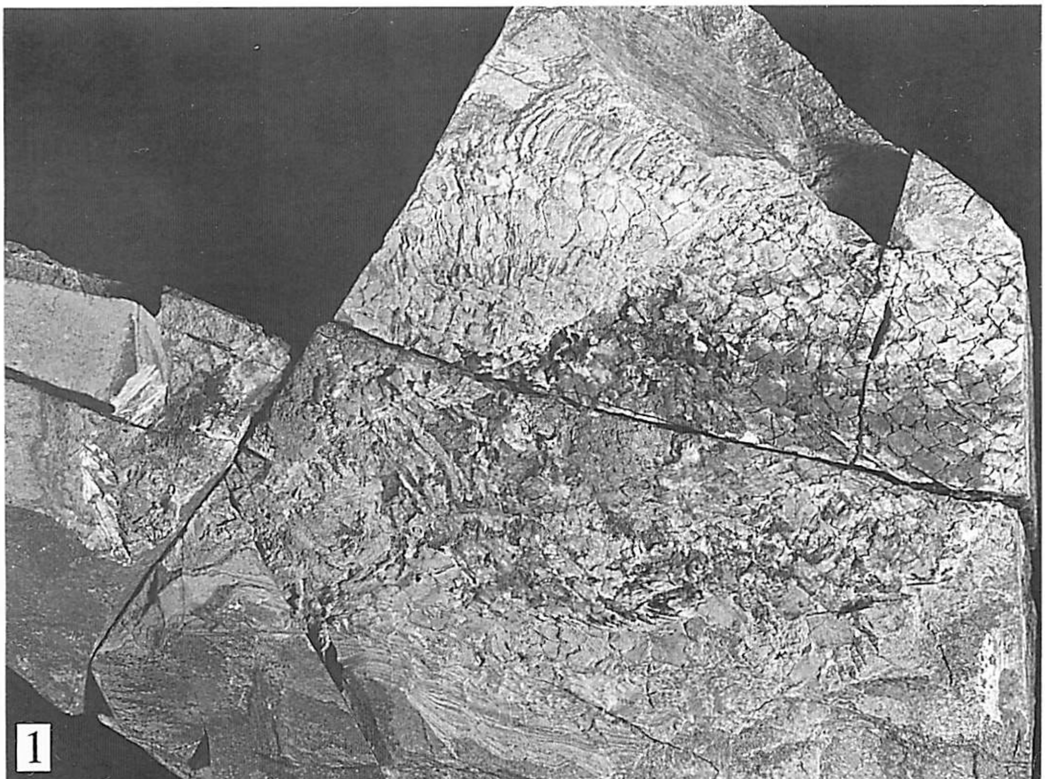
Early Cretaceous Freshwater Fish Fauna in Kyushu, Japan

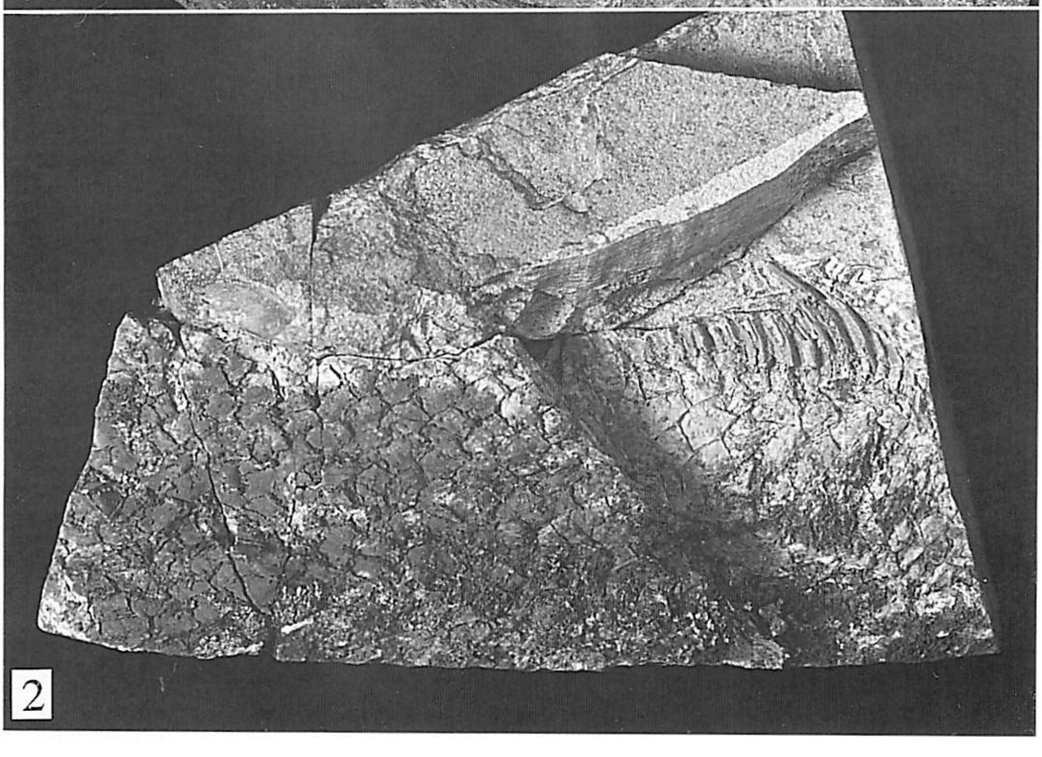
Yoshitaka YABUMOTO

Plates 36–59.

Explanation of Plate 36

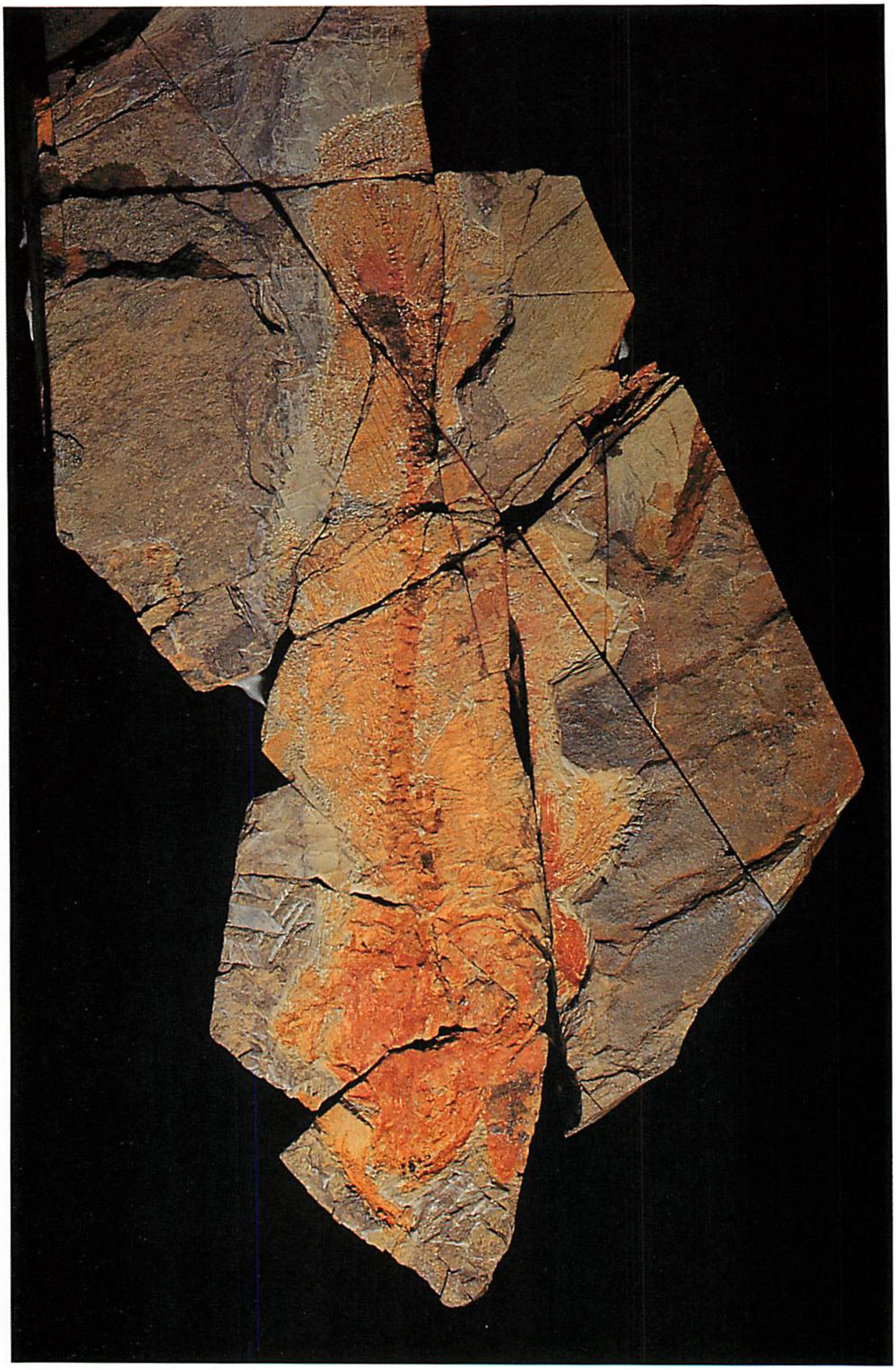
1. *Lepidotes macropterus* sp. nov., holotype, KMNH VP 100,146. ×1.3
2. *Lepidotes macropterus* sp. nov., holotype, KMNH VP 100,146, counter part. ×1.7





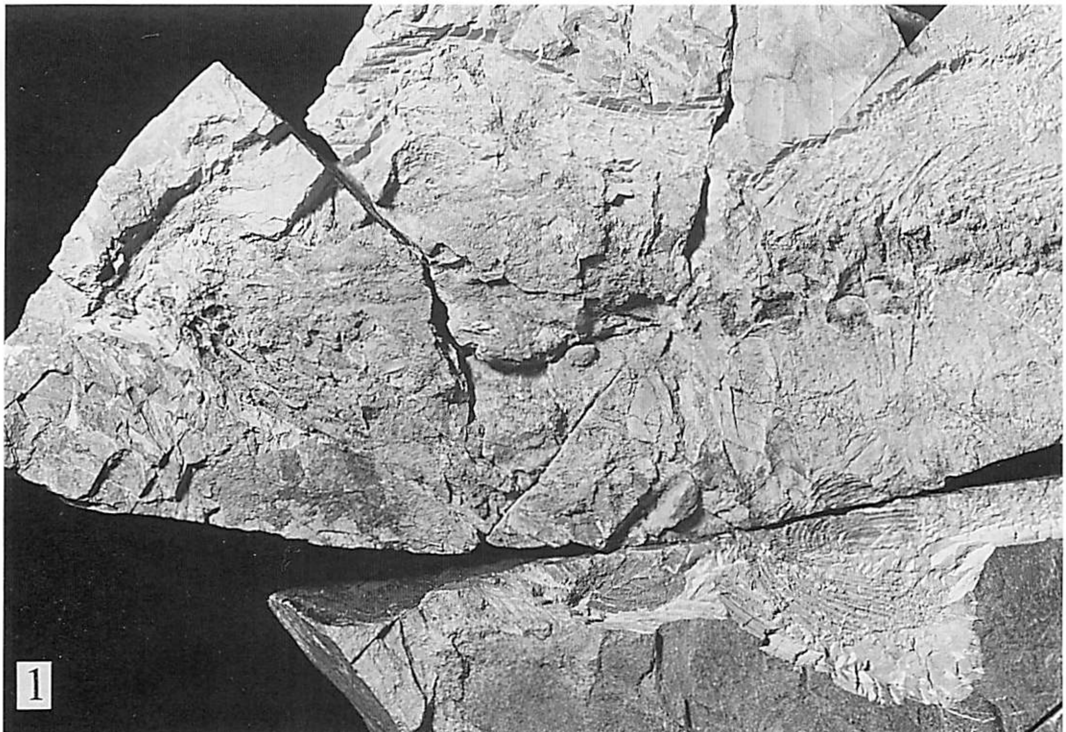
Explanation of Plate 37

Nipponamia satoi gen. et sp. nov., holotype, KMNH VP 100,147. ×0.6



Explanation of Plate 38

1. *Nipponamia satoi* gen. et sp. nov., holotype, KMNH VP 100,147, head region. ×0.9
2. *Nipponamia satoi* gen. et sp. nov., holotype, KMNH VP 100,147, caudal region. ×0.9



Explanation of Plate 39

Chuhsiungichthys yanagidai sp. nov., holotype, KMNH VP 100,148. ×1.2

Explanation of Plate 40

1. *Chuhsiungichthys yanagidai* sp. nov., holotype, KMNH VP 100,148, head region. ×1.5
2. *Chuhsiungichthys yanagidai* sp. nov., holotype, KMNH VP 100,148, caudal region. ×1.7

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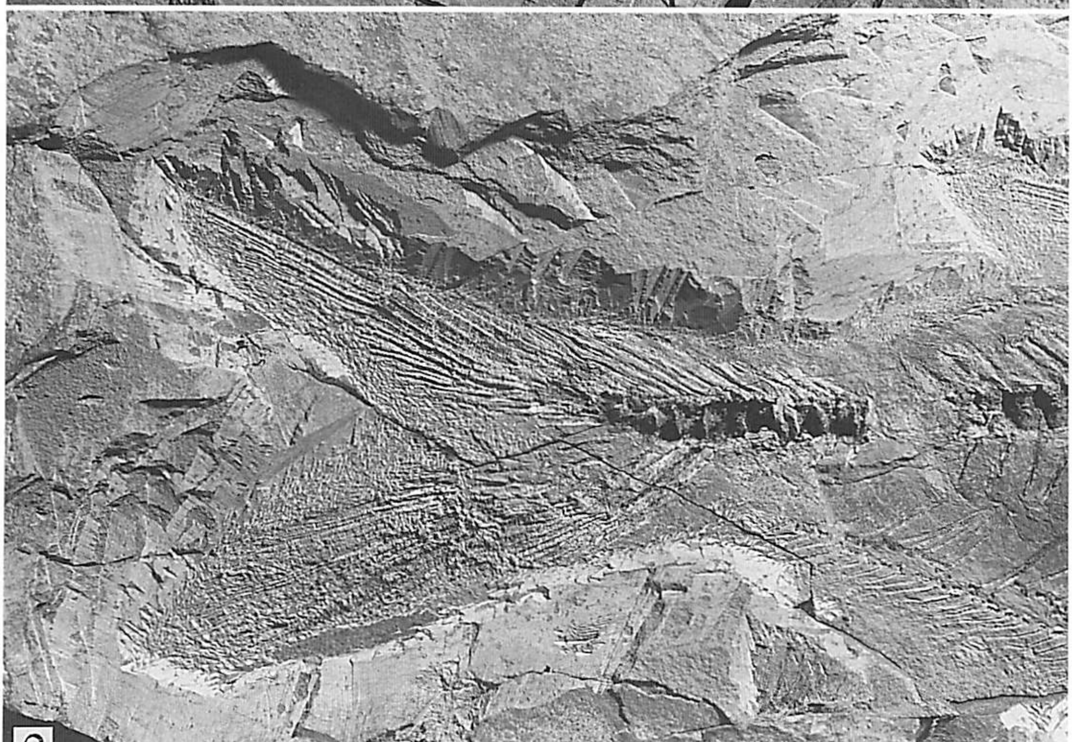

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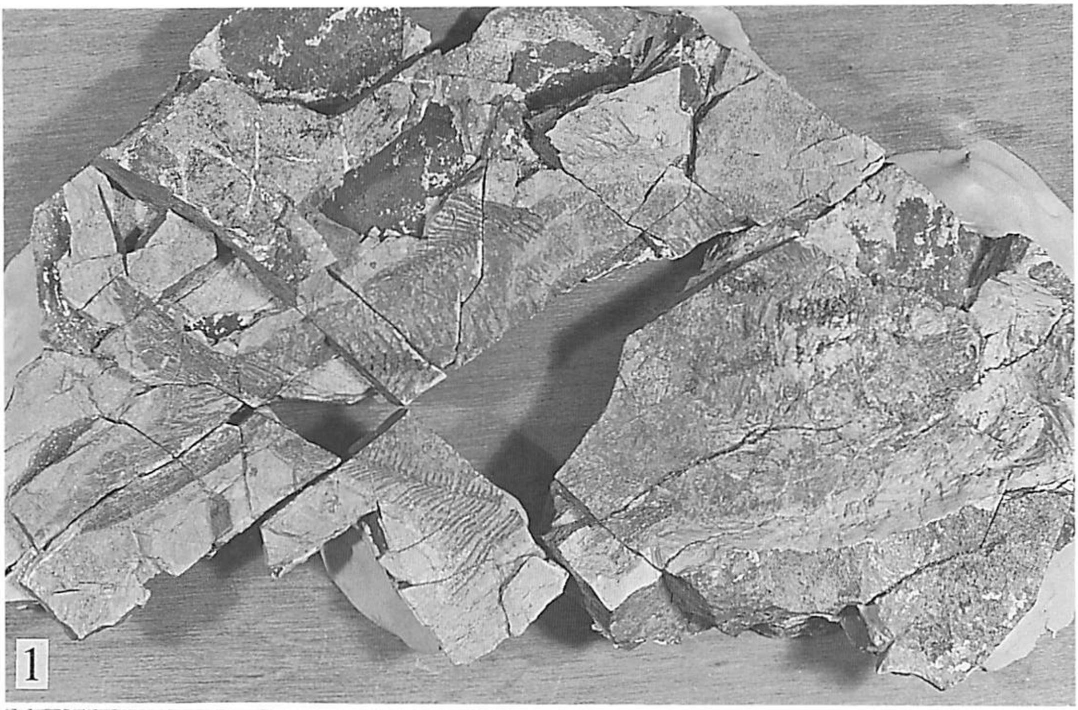
Explanation of Plate 41

1. *Chuhsiungichthys japonicus* sp. nov., holotype, KMNH VP 100,150. ×0.5
2. *Chuhsiungichthys japonicus* sp. nov., holotype, KMNH VP 100,150, caudal region. ×4.1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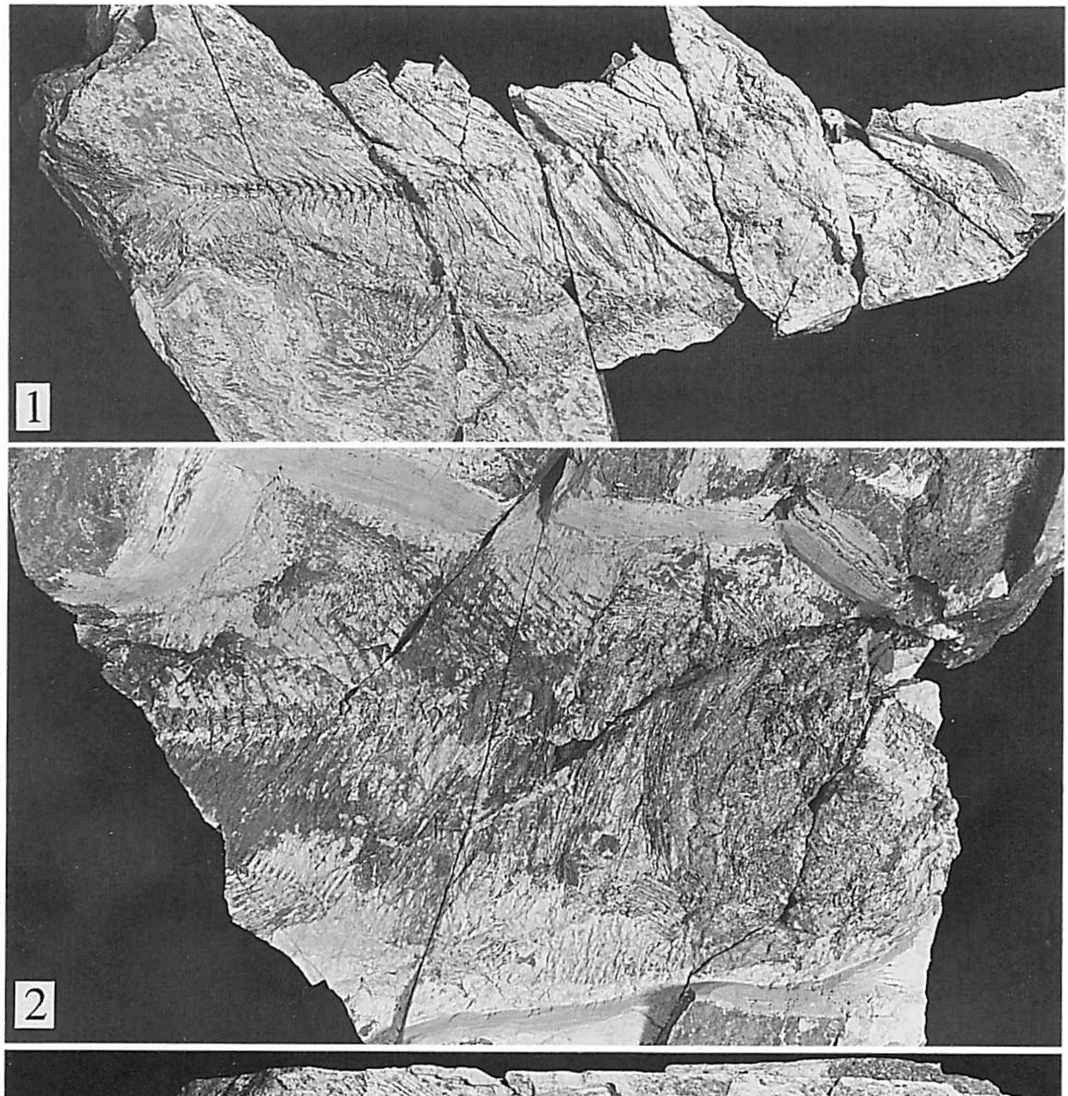
Explanation of Plate 42

1. *Chuhsiungichthys* sp., KMNH VP 100,152. ×0.9
2. *Chuhsiungichthys* sp., KMNH VP 100,153. ×1.0
3. *Chuhsiungichthys* sp., KMNH VP 100,154. ×1.0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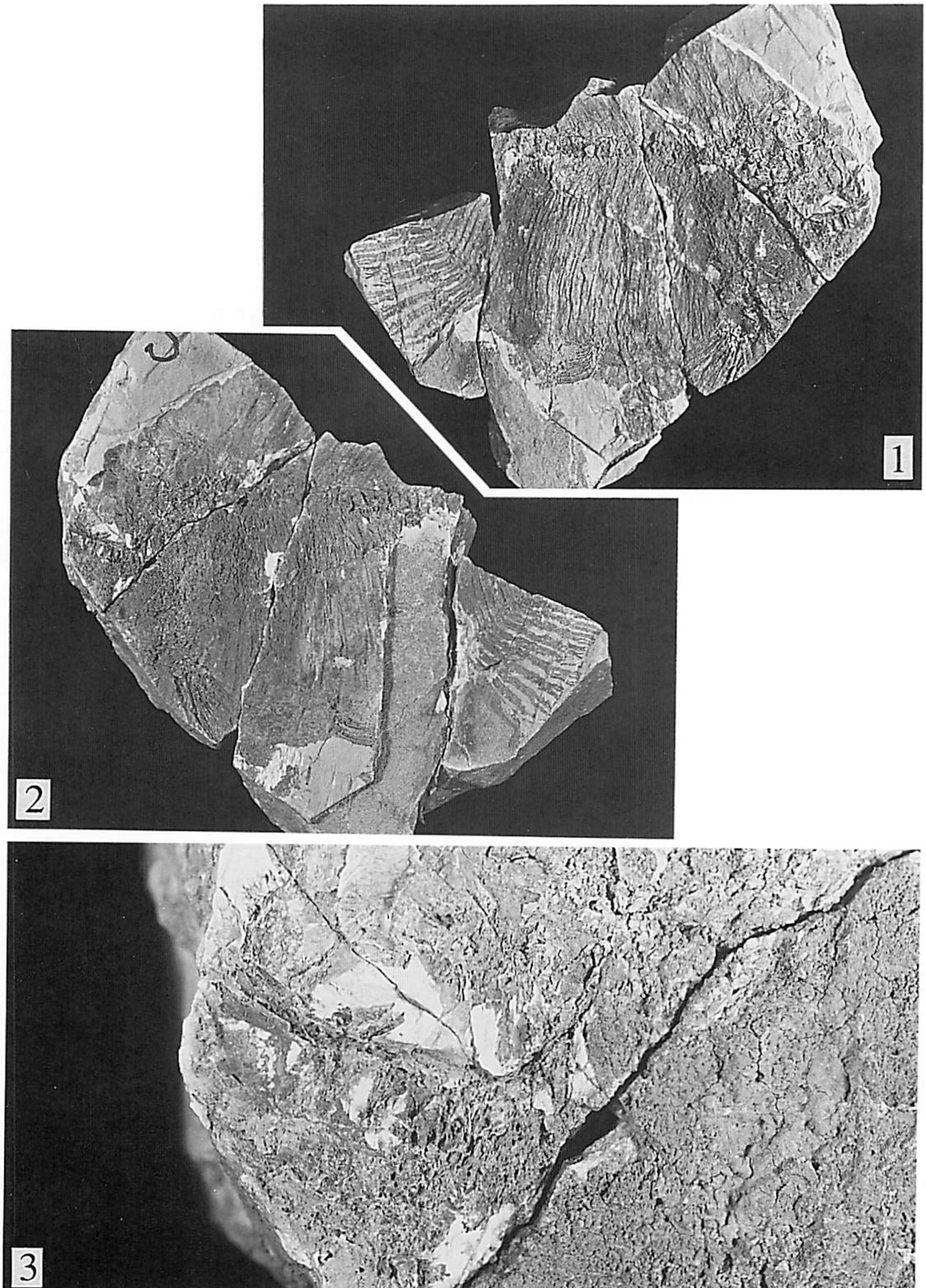
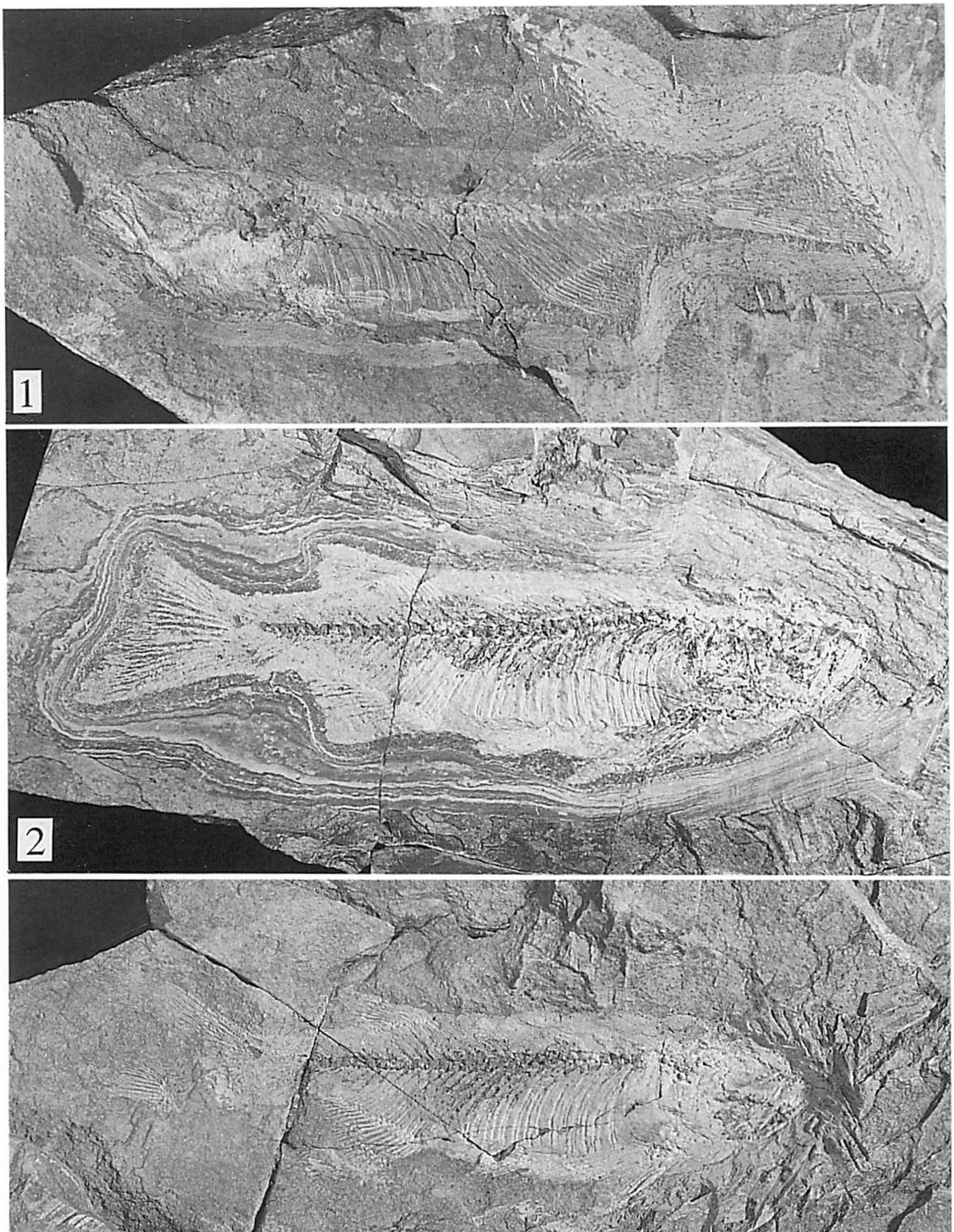
Explanation of Plate 43

1. *Yungkangichthys macrodon*. sp. nov., holotype, KMNH VP 100,183. ×0.8
2. *Yungkangichthys macrodon*. sp. nov., holotype, KMNH VP 100,183, counter part. ×0.8
3. *Yungkangichthys macrodon*. sp. nov., head region of the holotype, KMNH VP 100,183. ×3.8



Explanation of Plate 44

1. *Aokiichthys toriyamai* gen. et sp. nov., holotype, KMNH VP 100,160. ×2.6
2. *Aokiichthys toriyamai* gen. et sp. nov., paratype, KMNH VP 100,164. ×1.3
3. *Aokiichthys toriyamai* gen. et sp. nov., paratype, KMNH VP 100,165. ×1.3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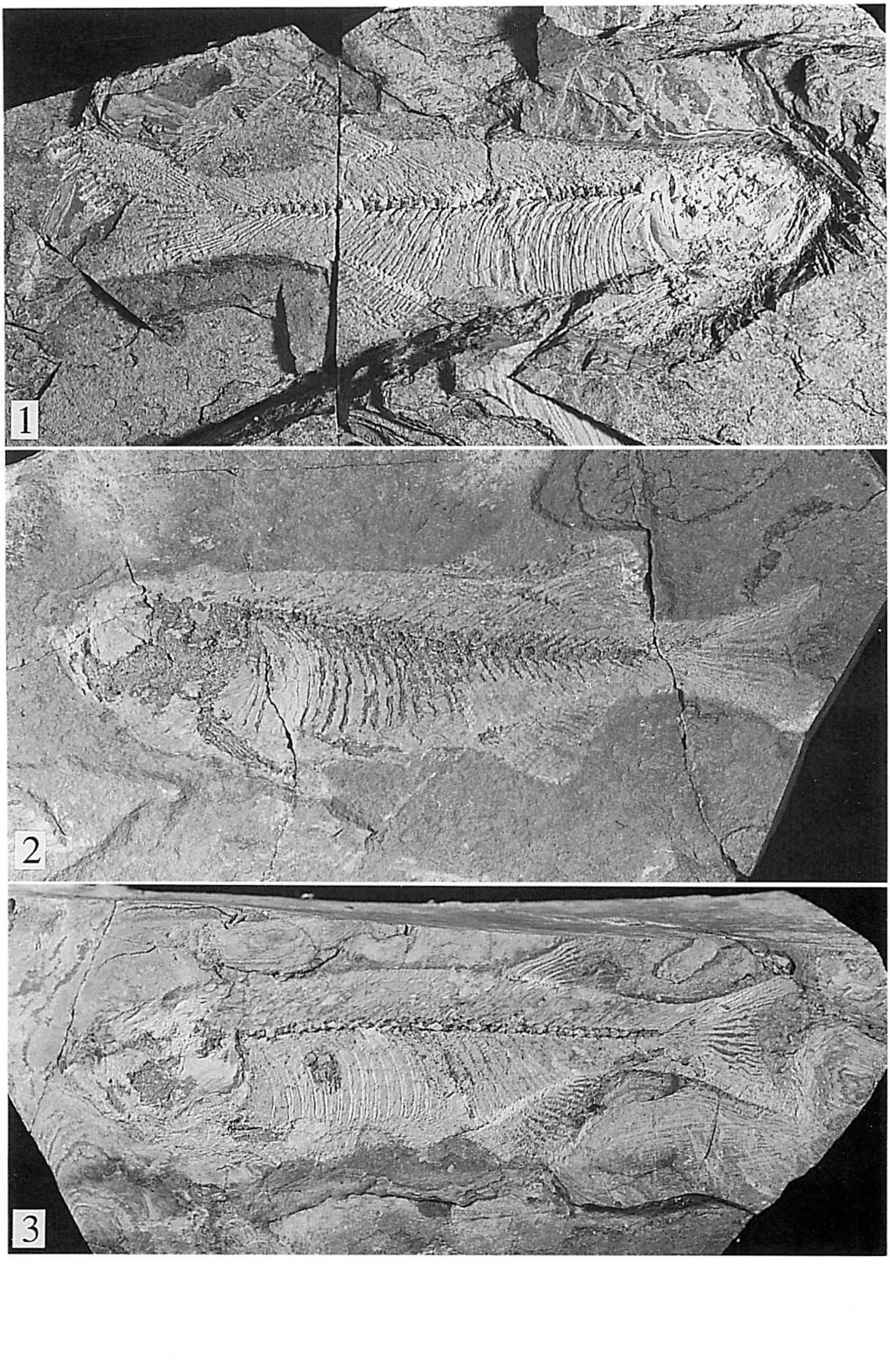
Explanation of Plate 45

1. *Aokiichthys changae* gen. et sp. nov., holotype, KMNH VP 100,166. ×1.5
2. *Aokiichthys changae* gen. et sp. nov., paratype, KMNH VP 100,167. ×1.6
3. *Aokiichthys changae* gen. et sp. nov., paratype, KMNH VP 100,168. ×1.3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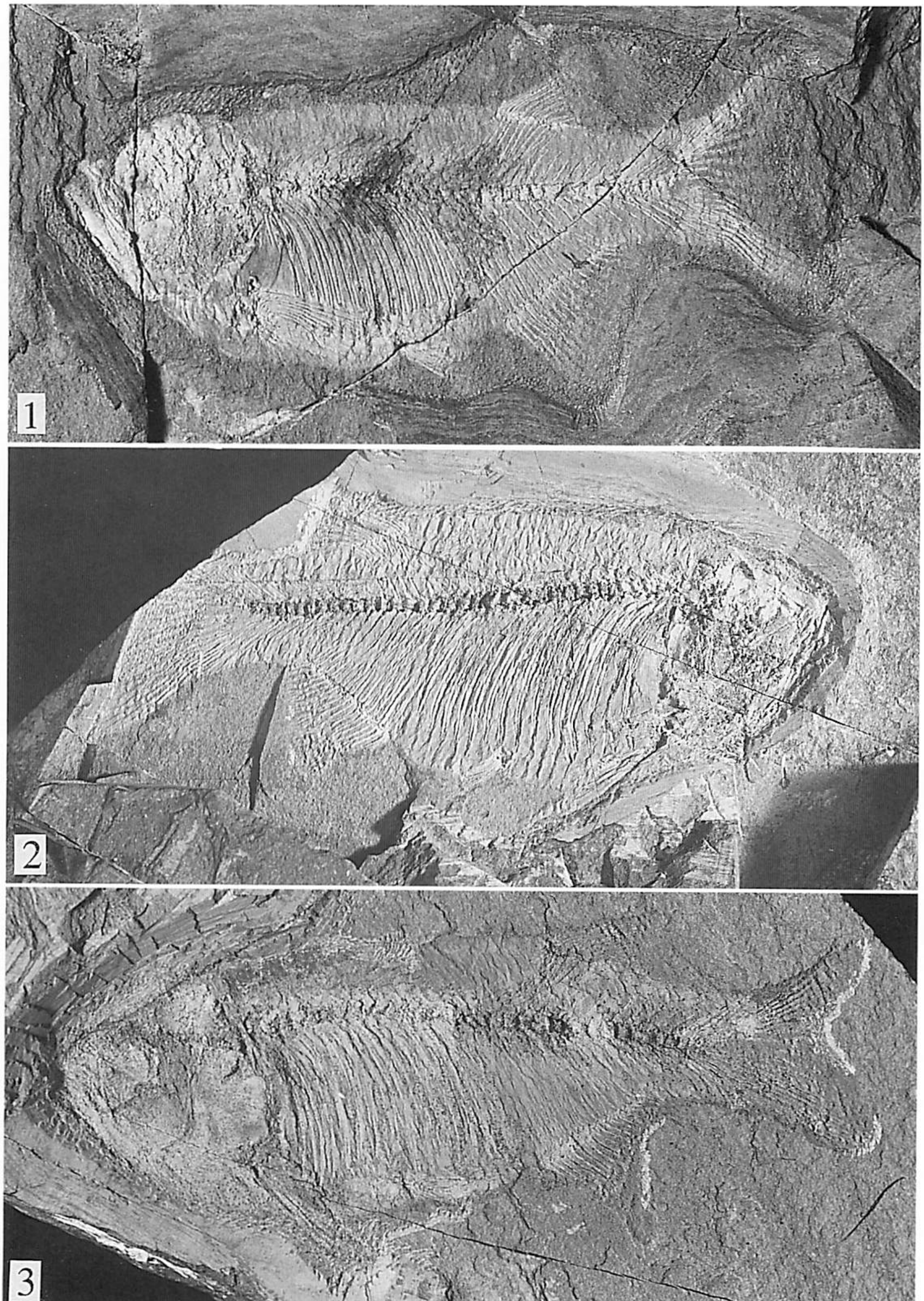
Explanation of Plate 46

1. *Aokiichthys otai* gen. et sp. nov., holotype, KMNH VP 100,173. ×1.7
2. *Aokiichthys otai* gen. et sp. nov., paratype, KMNH VP 100,174. ×1.6
3. *Aokiichthys otai* gen. et sp. nov., paratype, KMNH VP 100,175. ×1.7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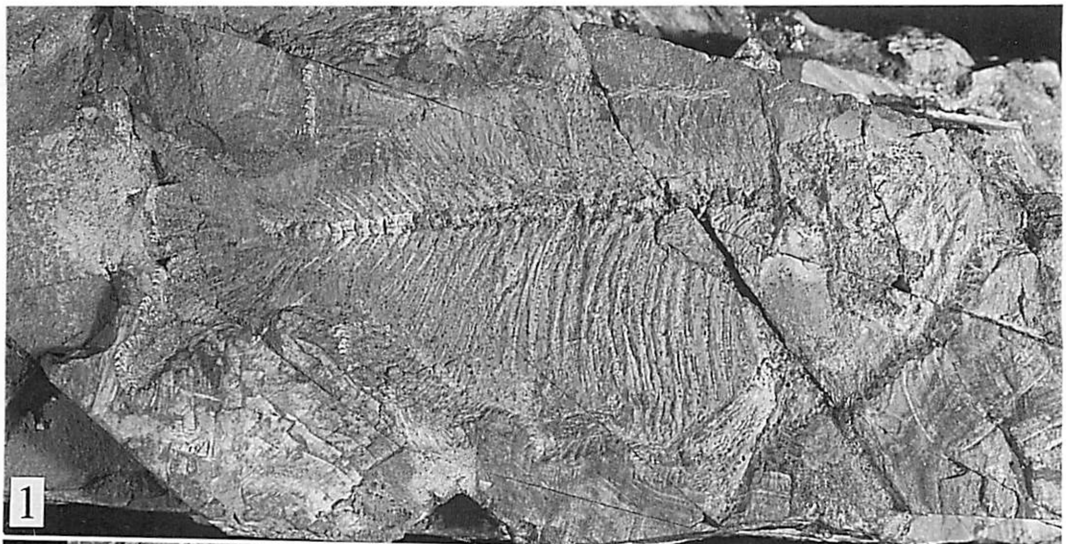
Explanation of Plate 47

1. *Aokiichthys uyenoi* gen. et sp. nov., holotype, KMNH VP 100,176. ×1.7
2. *Aokiichthys uyenoi* gen. et sp. nov., paratype, KMNH VP 100,179. ×1.9
3. *Aokiichthys uyenoi* gen. et sp. nov., paratype, KMNH VP 100,177. ×1.7



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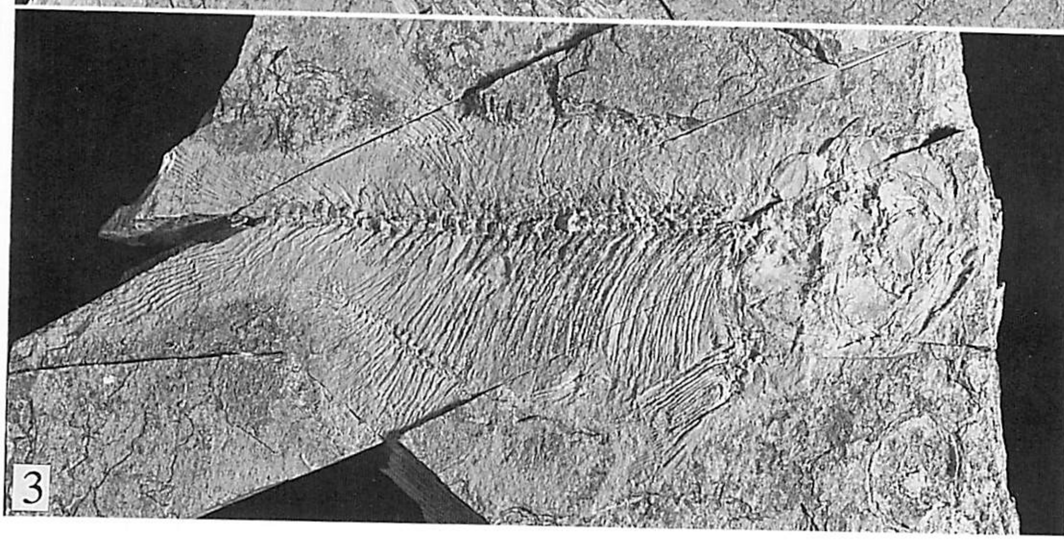

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Explanation of Plate 48

Aokiichthys praedorsalis gen. et sp. nov., holotype, KMNH VP 100,156. ×0.9

Explanation of Plate 49

1. *Aokiichthys praedorsalis* gen. et sp. nov., head region of the holotype, KMNH VP 100,156. ×1.7
2. *Aokiichthys* sp., KMNH VP 100,159. ×1.1

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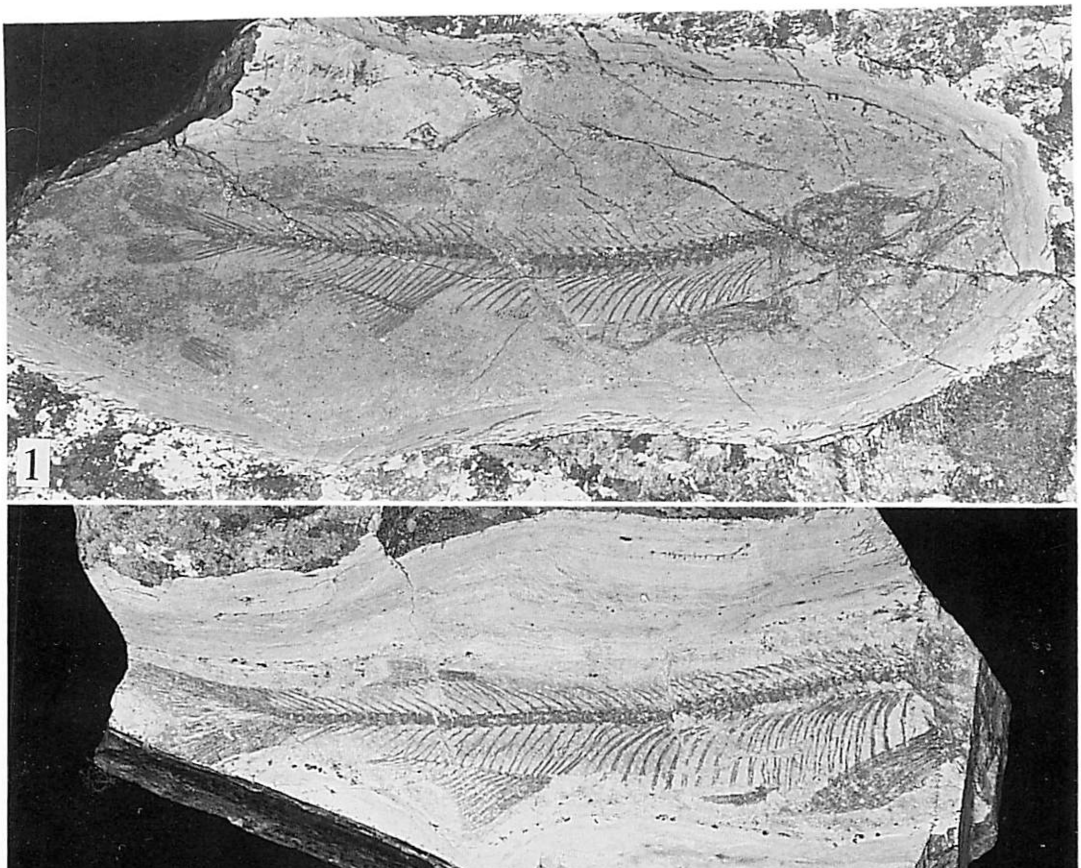
Explanation of Plate 50

Wakinoichthys aokii gen. et sp. nov., from the Fourth Formation (W_4).

1. *Wakinoichthys aokii* gen. et sp. nov., holotype, KMNH VP 100,140. ×1.5
2. *Wakinoichthys aokii* gen. et sp. nov., holotype, KMNH VP 100,142. ×1.3
3. *Wakinoichthys aokii* gen. et sp. nov., holotype, KMNH VP 100,143. ×1.0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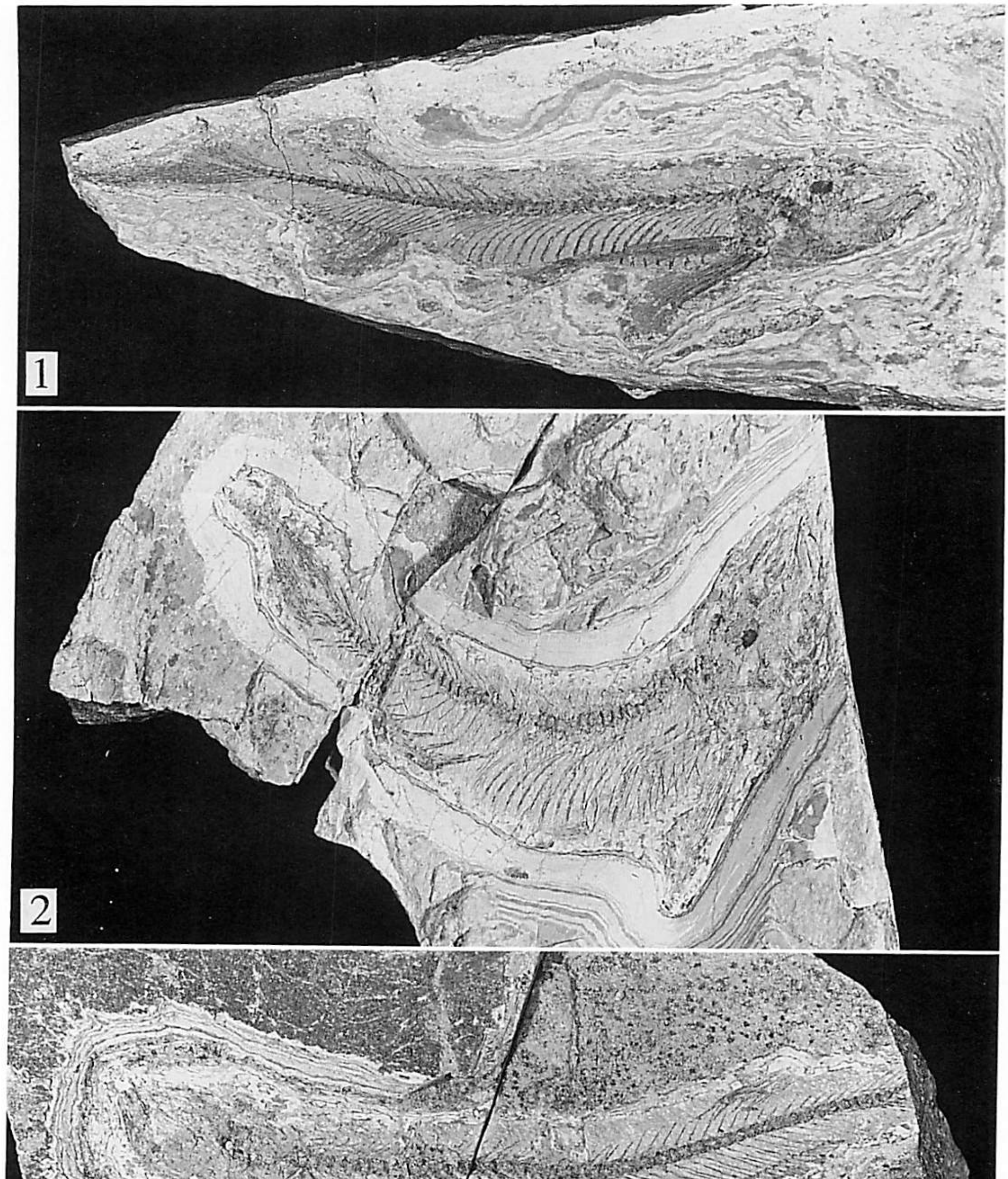
Explanation of Plate 51

Wakinoichthys aokii gen. et sp. nov., from the Third Formation (W_3).

1. *Wakinoichthys aokii* gen. et sp. nov., KMNH VP 100,184. ×1.7
2. *Wakinoichthys aokii* gen. et sp. nov., KMNH VP 100,182. ×1.7
3. *Wakinoichthys aokii* gen. et sp. nov., KMNH VP 100,186. ×1.6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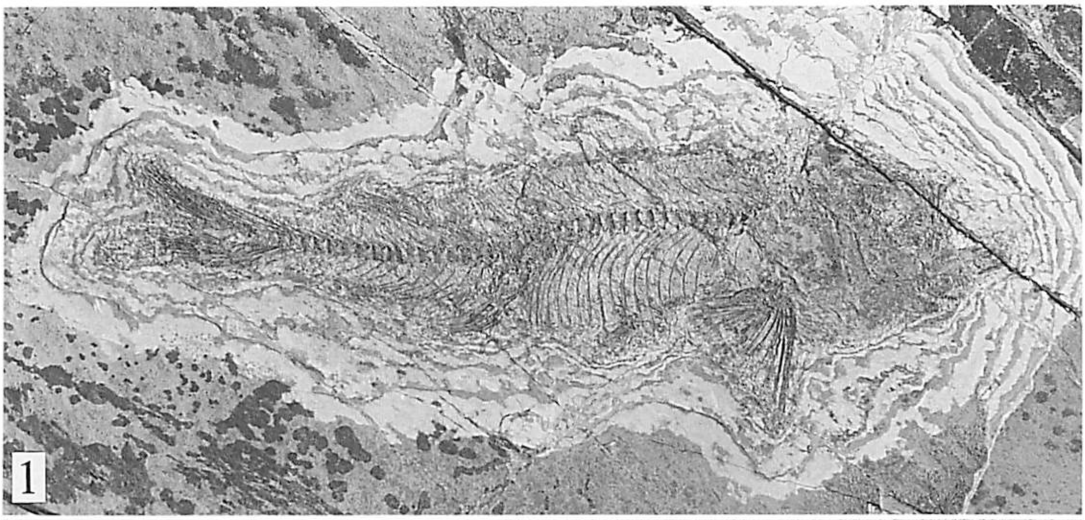
Explanation of Plate 52

1. *Wakinoichthys robustus* gen. et sp. nov., holotype, KMNH VP 100,188. ×2.5
2. *Wakinoichthys robustus* gen. et sp. nov., paratype, KMNH VP 100,189. ×3.0
3. *Wakinoichthys robustus* gen. et sp. nov., paratype, KMNH VP 100,191. ×4.1



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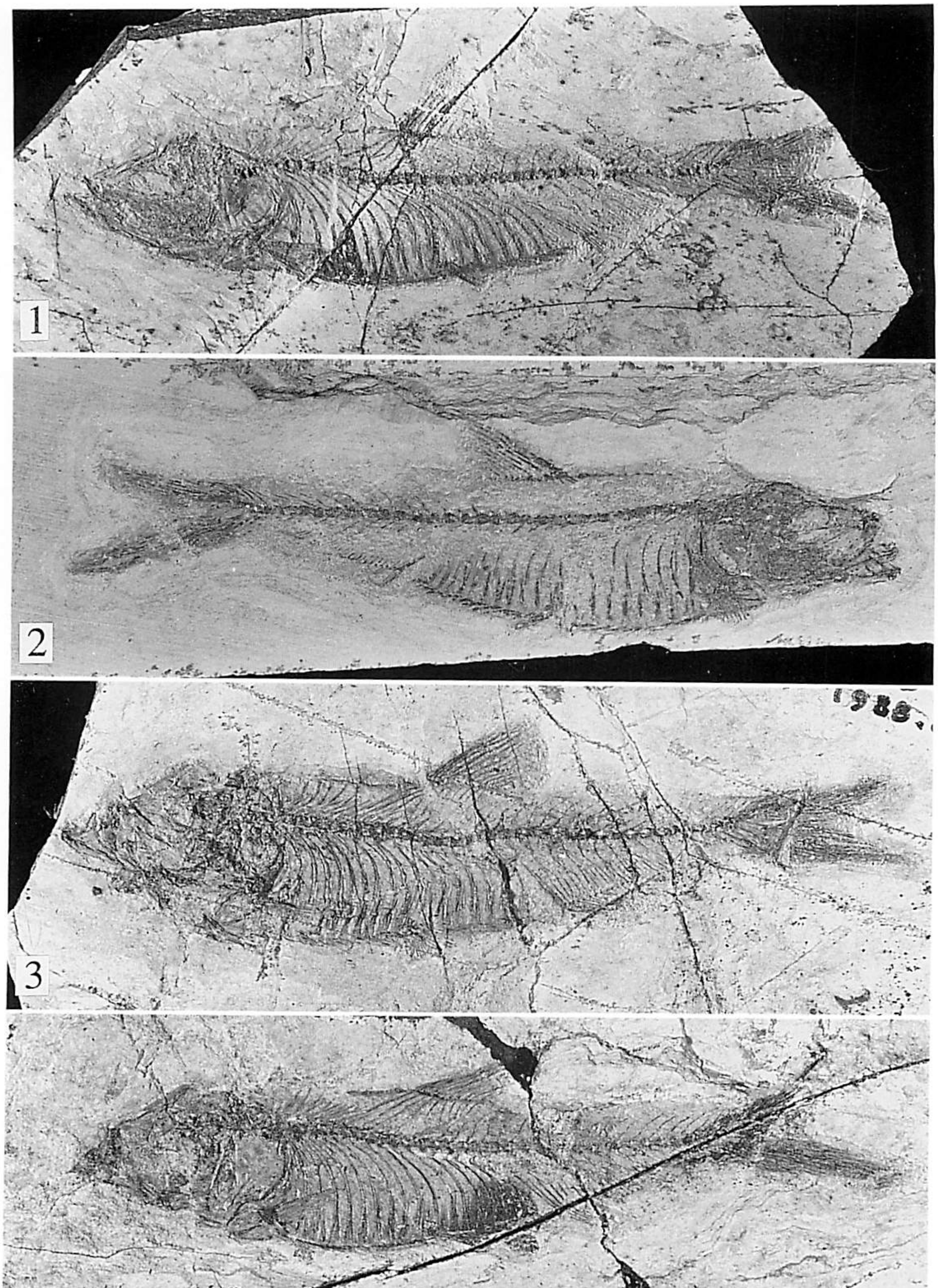
Explanation of Plate 53

1. *Diplomystus primotinus* Uyeno, 1979, KMNH VP 100,194. ×2.1
2. *Diplomystus primotinus* Uyeno, 1979, KMNH VP 100,196. ×1.9
3. *Diplomystus primotinus* Uyeno, 1979, KMNH VP 100,198. ×1.9
4. *Diplomystus primotinus* Uyeno, 1979, KMNH VP 100,199. ×2.8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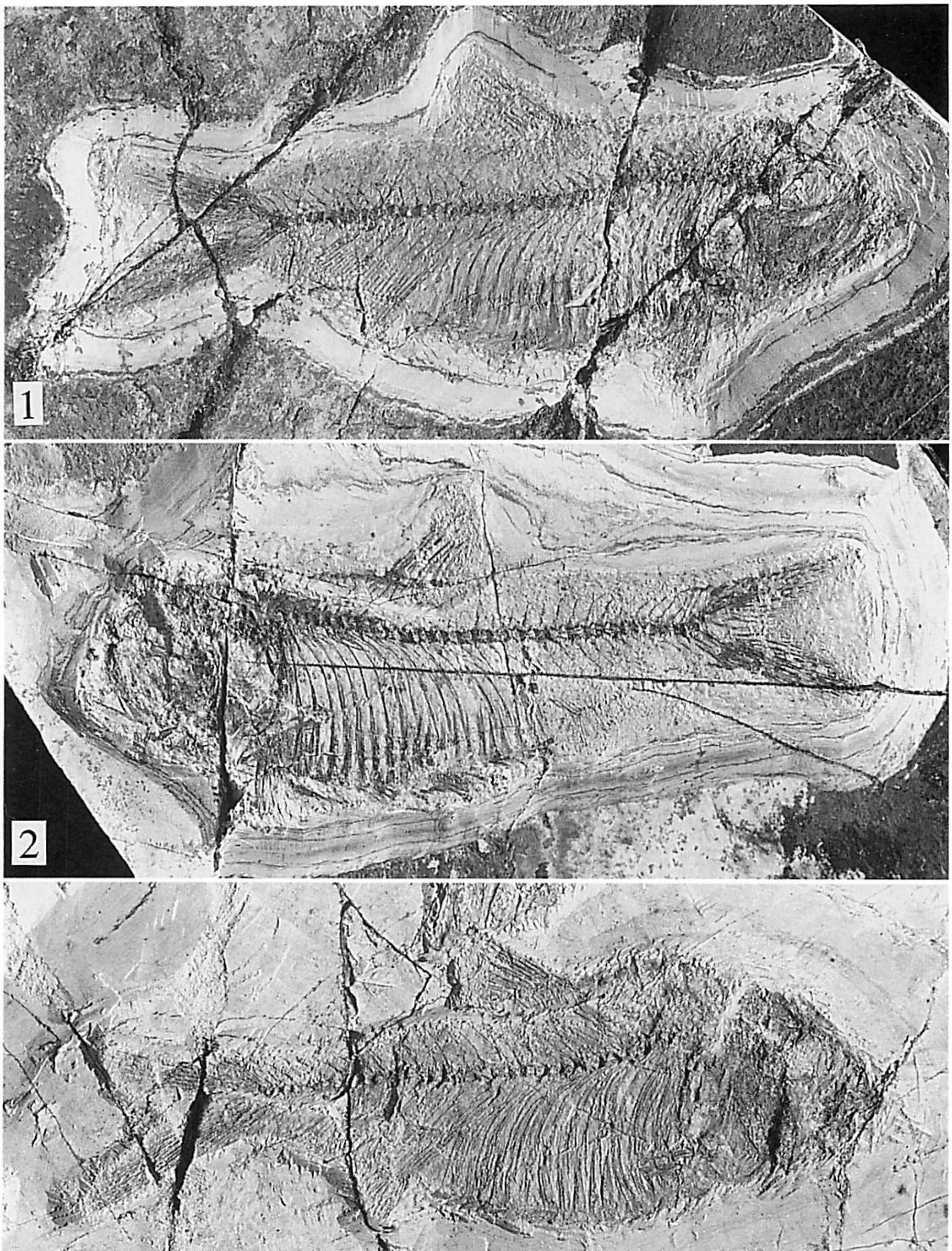
Explanation of Plate 54

1. *Diplomystus kokuraensis* Uyeno, 1979, KMNH VP 100,206. ×1.6
2. *Diplomystus kokuraensis* Uyeno, 1979, KMNH VP 100,207. ×1.9
3. *Diplomystus kokuraensis* Uyeno, 1979, KMNH VP 100,204. ×1.8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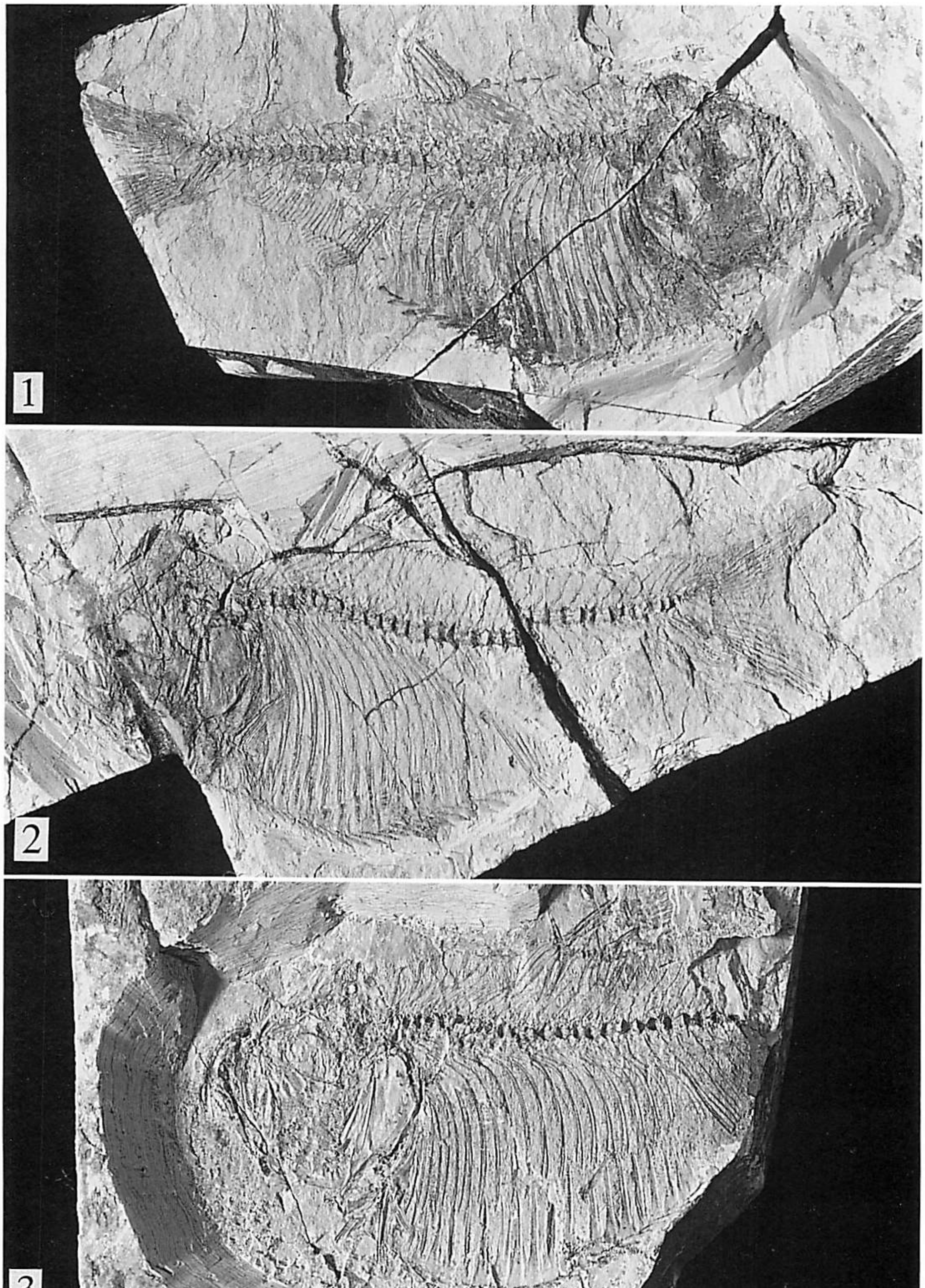
Explanation of Plate 55

1. *Diplomystus altisomus* sp. nov., holotype, KMNH VP 100,217. ×2.1
2. *Diplomystus altisomus* sp. nov., paratype, KMNH VP 100,221. ×3.3
3. *Diplomystus altisomus* sp. nov., paratype, KMNH VP 100,219. ×2.0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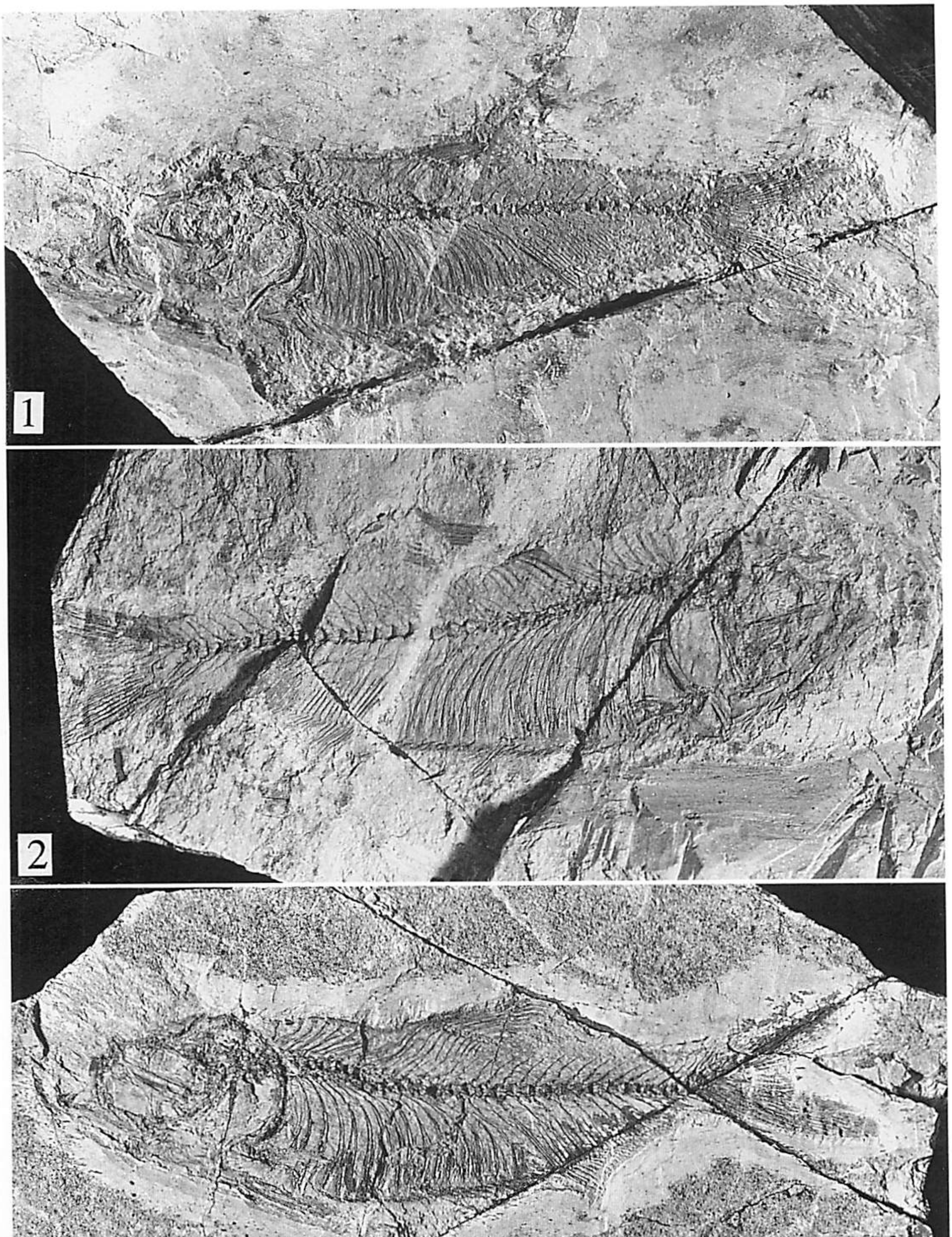
Explanation of Plate 56

1. *Diplomystus* sp., KMNH VP 100,211. ×2.4
2. *Diplomystus* sp., KMNH VP 100,234. ×1.9
3. *Diplomystus* sp., KMNH VP 100,223. ×1.9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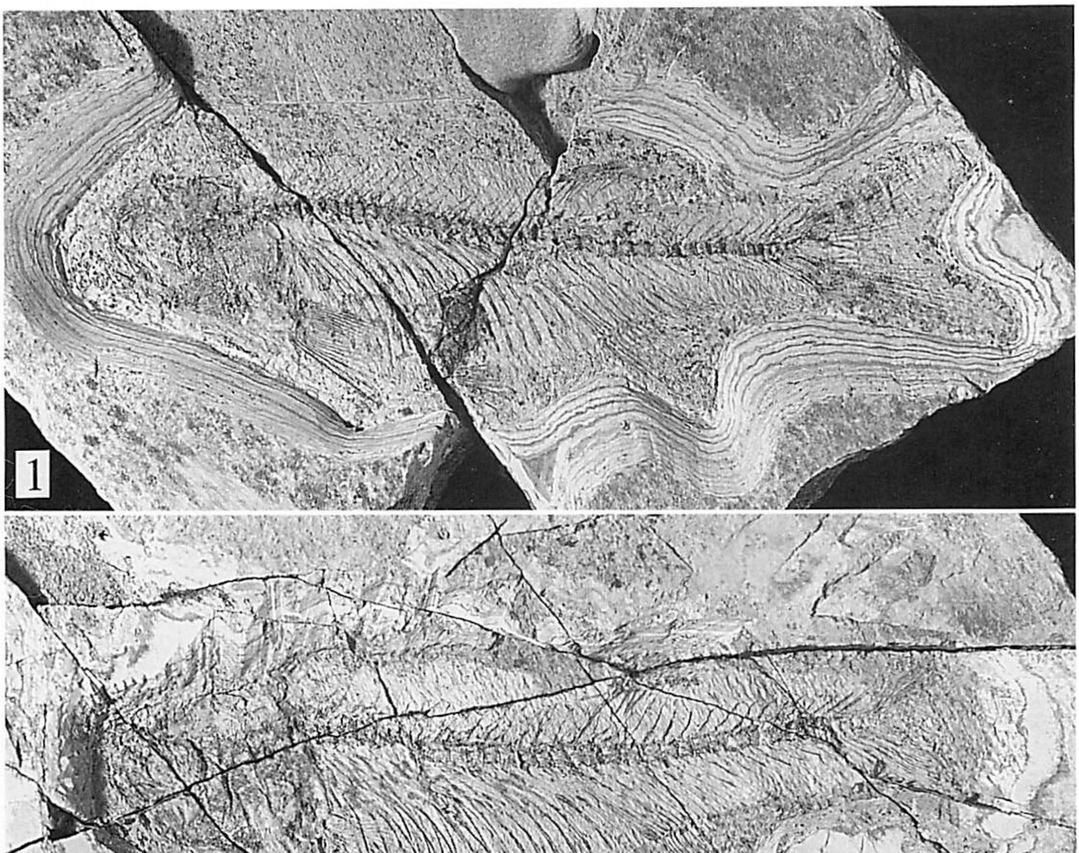
Explanation of Plate 57

1. *Paraleptolepis kikuchii* gen. et sp. nov., holotype, KMNH VP 100,222. ×1.7
2. *Paraleptolepis kikuchii* gen. et sp. nov., paratype, KMNH VP 100,223. ×2.2
3. *Paraleptolepis kikuchii* gen. et sp. nov., paratype, KMNH VP 100,225. ×4.6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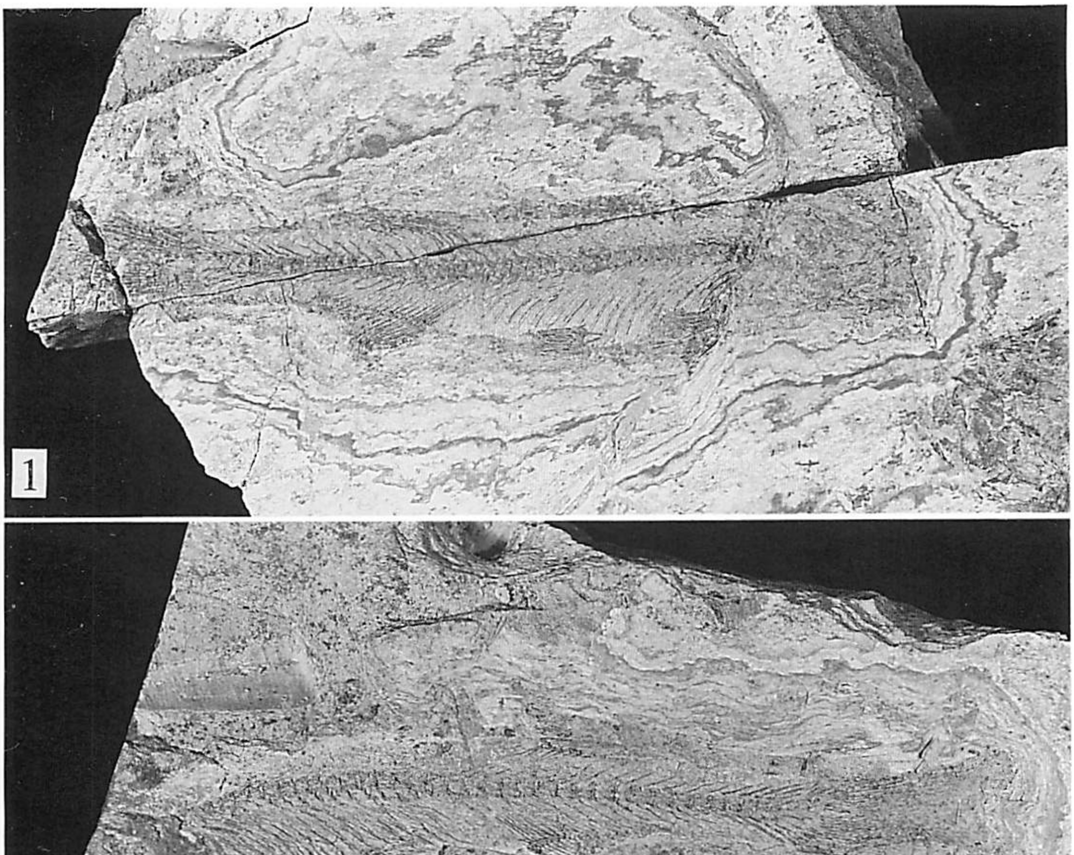
Explanation of Plate 58

1. *Paraleptolepis elegans* gen. et sp. nov., holotype, KMNH VP 100,227. ×1.9
2. *Paraleptolepis elegans* gen. et sp. nov., paratype, KMNH VP 100,228. ×2.0
3. *Paraleptolepis elegans* gen. et sp. nov., paratype, KMNH VP 100,231. ×1.7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Explanation of Plate 59

1. *Paraleptolepis elegans* gen. et sp. nov., paratype, KMNH VP 100,229. ×2.1
2. *Paraleptolepis elegans* gen. et sp. nov., paratype, KMNH VP 100,230. ×3.4
3. Gonorynchiformes ? *incertae sedis,* KMNH VP 100,233. ×2.7


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